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Atmospheric Structure and Its Variations in the Region From 25 to 120 km

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13. ABSTRACT

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Abstract

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1. INTRODUCTION

Since the preparation of COSPAR International Reference Atmosphere (CIRA) 1965 [1], there has been a substantial increase in the number of measurements of atmospheric structure by sounding rockets. This is particularly true in the region below 60 km, which is accessible by meteorological rockets. At greater heights, the smaller numbers of new measurements, using for example the falling sphere and grenade techniques, have nevertheless made a relatively important contribution up to 90 km. Above this level, data are sparsely distributed until the region of orbiting satellites is reached. Analyses of satellite orbital decay from 200 to 1000 km have shown that atmospheric temperatures and densities depend on solar activity, local time and other parameters which, at rocket heights (below 90 km), are difficult or impossible to identify. On the other hand, the main variations shown by rocket data are with season and latitude; and these variations are almost completely absent at satellite heights.

In CIRA 1965 models of W-E winds as well as of temperatures, pressures and densities were presented from 30 to 80 km for different latitudes and times of the year. S. Hemisphere data, which were relatively few, were utilized as N. Hemisphere data with a 6-month change of date. Tabulations of the models were at intervals of 5 km in height, 10^{0} in latitude and one month in time. An indication

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of the departure of atmospheric temperatures and W-E wind speeds from those of the models was provided by 50 percent probability limits for summer and winter periods. These deviations showed that variability (i) increased with height, and (ii) was much greater in winter than summer, particularly at mid- and high-latitudes.

The limitations of the CIRA 1965 seasonal-latitudinal models stem from the uneven distribution of data in time, height and geographical location:

(i) Few measurements were available near the equator or in the polar regions, and a considerable gap existed at midlatitudes.

(ii) Most measurements had been made over the N. American continent.

(iii) The quantity of available data decreased rapidly with height above 60 km.

(iv) Most observations were from the years 1961-63 with decreasing numbers of observations from earlier years.

These limitations were pointed out in CIRA 1965. Also referred to in CIRA 1965 were diurnal variations and the quasi-biennial oscillation (QBO). Diurnal variations of tidal origin are observed in winds at meteor ionization heights and in the lower ionosphere. They are present at lower heights with generally smaller amplitudes in all atmospheric parameters. Unfortunately, the data provided by meteorological rockets at these lower heights have usually been taken close to local noon, and for CIRA 1965 no information on the diurnal dependence could be included. The models below 60 km, therefore, tend to be biassed towards local noon conditions. The QBO is most apparent in stratospheric W-E winds at low latitudes. It was first observed in balloon data and then in rocket data after launchings commenced at Ascension Island (8^{o}S) in October 1962. The QBO has now been followed over three cycles at this site, but at the time of preparation of CIRA 1965 the available data were insufficient for a detailed analysis.

Since late 1963, many new rocket launching sites have been brought into operation. Also, ground-based radio methods of wind measurement at meteor heights and in the lower ionosphere have been undertaken at new sites during recent years. New results on winds, temperatures and densities in the stratosphere, mesosphere and lower thermosphere have been presented at COSPAR Working Group 4 Open Meetings 1966-70 and progress in this field has been kept under annual review [2].

New CIRA models have now been prepared which are based on a further six years of observational data. The new models extend the CIRA 1965 models above 80 km and enlarge them in various other ways to be discussed later. As with CIRA 1965, the basis of the new study has been observational and the form which the models take has been largely dictated by the distributions of available data. Limitations still arise due to the particular distributions of available data in time, height and geographical location. High-latitude wintertime conditions are particularly difficult to represent.

A large amount of new data has been acquired in recent years by meteorological rockets with the result that in the region of 60 km the sharp fall-off in data with height has become even sharper, necessitating different procedures for handling data below and above 60 km. Temperature, pressure and density models for the two height regions have been joined together and run continuously from 25 to 110 km. There are, however, three W-E wind models for the 25- to 60-km region and these are presented separately from the 60- to 130-km model. It has been found convenient to divide the atmosphere into regions below and above 60 km in the following discussion of observing methods and results.

2. ATMOSPHERIC STRUCTURE 25 TO 60 KM

2.1 Rocket Measuring Techniques

2. 1. 1 METEOROLOGICAL ROCKET SYSTEMS

A recent review of meteorological rocket techniques is available in reference [3]. Extensive use has been made of the ARCAS and LOKI-DART rocket systems in the U. S. A. and elsewhere, and more recently the gun-launching of probes has become a regular procedure at certain sites. These systems and their respective payloads are discussed in reference [3]; other systems discussed are the British SKUA rocket, the Polish METEOR-1 system and the Australian KOOKABURRA. Another relevant publication is that by Ballard [4] in the COSPAR Technique Manual Series. This describes in considerable detail the ARCAS and LOKI systems and provides a useful guide to groups planning meteorological rocket observations with these or other systems.

2. 1. 2 WIND MEASUREMENT

The most frequently used sensor for wind measurement below 60 km has been a parachute or similar device which also serves to decelerate a temperature-measuring instrument package. Tracking by radar gives S-N, W-E and vertical velocity components from which horizontal wind components are derived. The wind response of parachute sensors is poor above 50 km [5], but useful results may be obtained to about 65 km by applying a correction which is proportional to the rate-of-change of horizontal velocity. Even so a residual error is present depending on the type of radar in use. For MRN (Meteorological Rocket Network) facilities the rms vector wind errors have been estimated as typically 4 m/s [6]. Gliding or sailing of the parachute is believed to contribute significantly to this error. The lowest level to which wind results can be obtained often depends on the parachute remaining within radar tracking range. Profiles can usually be taken down to balloon levels. The formation of the MRN was in October 1959, and

up to 1969 observations of the wind structure had been obtained from about 12,000 rocket launchings. This number is increasing at the rate of about 1,000 per year. Over 6,000 of these launchings employed parachutes with sondes for temperature measurement. Of the remainder over 3,000 used radar chaff in the LOKI-type rocket.

The very low mass/area ratios available with chaff make it a suitable wind sensor above 65 km. In launchings at Point Barrow, Alaska [7] and Arenosillo, Spain [8] wind data have been obtained at 95 to 100 km and extended down to 75 to 80 km before the chaff diffused too much for further tracking. Other advantages of chaff are its low weight and the feasibility of using it in boosted dart vehicles. Wind profiles are then obtained over approximately the same altitude range as with parachute sondes of the ARCAS-type. Wind accuracies obtained with chaff vary greatly depending on the type of chaff used, the height of release and the time that has elapsed since release. No recent estimates of accuracy appear to be available. A value of 12 m/s for the rms error of the wind vector at 70 to 85 km was derived in 1960 from simultaneous observations by two radars on 10 chaff soundings [9].

Inflated falling spheres are also effective as wind sensors to greater heights than parachutes on account of their lower mass/area ratio. Such advantage is slightly reduced if release heights are increased in order to obtain densities from sphere deceleration. At the Carnarvon and Woomera ranges, Australia, wind data have generally been obtained from 75 km downwards. From 1960 to 1969 the following numbers of releases of the ROBIN 1 metre inflated sphere were made with the MRN [10]: Ascension Is. (8°S) 93, Kwajalein Is. (9°N) 11, Antigua AFB, BWI (17°N) 27, Cape Kennedy, Fla. (28°N) 55, Eglin AFB, Fla. (30°N) 161, Holloman AFB, N.M. (33°N) 19, Wallops Is., Va. (38°N) 14. The rms vector wind errors for the ROBIN sphere have been given as $\frac{1}{2}$ m/s below 50 km increasing to 3 m/s between 60 and 70 km [11].

In general the wind error depends on the type of sensor, its fall rate, the method of tracking and type of equipment used, the structure of the atmosphere and the time interval over which the raw data are smoothed or averaged [12].

2.1.3 TEMPERATURE MEASUREMENT

Above 40 km, accurate temperature measurement by means of a bead or wire "immersion" sensor requires corrections to be applied for dynamic heating and radiation effects. Such corrections have been derived theoretically after careful study of the heat transfer equation and the various transfer processes involved. The work of Wagner [13] was adopted by the MRN for correcting thermistor temperatures and is summarised in reference [4]. The thermistor is a 10-mil semiconductor bead, coated to minimize solar radiational heating. Unwanted heat reaches the thermistor via its mount, and various designs of mount have been

introduced in an effort to minimize the effect. Above 55 km, aerodynamic heating is probably the major extraneous effect due to the fast rate of descent. Typical corrections are -5.0°C at 50 km with an error variability of ±3.5°C and -19.0°C at 60 km with an error variability of ±5.0°C.

For CIRA 1965, MRN temperature data were not used above 50 km on account of the rapidly increasing magnitude of the correction with height. The evidence from ARCAS launches which have accompanied grenade launches (at, for example, Fort Churchill) is that the above limits of uncertainty may be exceeded for daytime launchings at heights above 50 km [14]. However further examination [3] of the heat transfer theory for the spherical bead thermistor has indicated a correction of -4.5°C with maximum uncertainties of ±3.5°C at 60 km and of -1°C with ±2.0°C uncertainty at 50 km, the range of uncertainty being even less than Wagner's. Attention has therefore been given to the effects of parachute dynamics as a possible source of error and to the improvement of parachute stability at lower dynamic pressures, in order to improve temperature measurement at greater heights. In view of these uncertainties, the same procedure has been followed as with CIRA 1965 and MRN temperatures have not been used above 50 km in compiling the new tables. A maximum altitude of 55 km for reasonably reliable temperature data in routine soundings has been put forward [12].

A temperature sensor of the resistance wire type has been used in the Skua sonde system in launchings at West Geirinish (57°N, 7°W) and other sites. Theoretical corrections are again calculated from the heat transfer equation, but are obtained more accurately for nighttime than daytime conditions, on account of the large solar radiation effect. Consequently, almost all data have been obtained at night. Comparisons are given below (Section 4.2.3) between Skua temperature measurements at West Geirinish and the new models. (No Skua data were used in the preparation of the temperature models following the decision to base these on the longitude range 70°W to 160°W, but data obtained at other longitudes such as West Geirinish have been compared with the models.)

Temperature errors, like wind errors, depend on a number of factors, some of which may vary from one launching to another; for example, aerodynamic and radiational heating are influenced by parachute dynamics [12]. At present it is usual practice to apply standard corrections to all launchings.

2.2 Data Available

2.2.1 WIND DATA

Launch sites providing wind data below 60 km are listed in Table 1 for the N. Hemisphere and Table 2 for the S. Hemisphere. Many new sites have been brought into operation since the preparation of CIRA 1965 and these are marked

with an asterisk. The numbers of profiles shown relate to those available in mid-1970 when the wind model analysis was undertaken. MRN monthly data reports, which provided the bulk of the data, had then been issued up to December 1968. A few 1969 and early 1970 data were available directly from experimenters. Meteorological rocket techniques have provided almost all the data listed, the remainder coming from grenade experiments. In the case of Point Barrow (71°N), 12 of the 20 profiles were from grenade experiments. For six MRN sites, which have been operational over many years with frequent launchings, the monthly mean values as published in the MRN monthly reports were utilized in place of the individual profiles.

The distribution of N. Hemisphere sites in longitude is very uneven. Most sites are located on the N. American continent and surrounding ocean areas. Sites northwards of 25°N are therefore grouped into two ranges of longitude: one headed "N. America" which lies between 69°W and 119°W and one headed "Europe/W. Asia" which lies between 7°W and 67°E. Very few N. Hemisphere observations are available outside these ranges of longitude at mid- and high-latitudes, and consideration of longitudinal effects is accordingly limited.

2.2.2 TEMPERATURE DATA

Table 3 lists launching sites which have provided temperature data up to 60 km. The list is similar to that for the winds except for a few stations where only winds have been observed. MRN data were available up to December 1968 at the time of the analysis. As with the winds, use was made of mean monthly values for certain stations in place of the individual profiles. Grenade and falling sphere methods provide the data input at 55 and 60 km, MRN values not being utilized at these heights as discussed above.

Launch sites between 70 and 160 °W are grouped together in Table 3 as only data from these sites were used in development of the models. The somewhat smaller number of measurements from outside this longitude range were utilized in comparisons with the model. Sufficient temperature data were not available from Europe or any other region to form a second grouping.

2.3 N. Hemisphere Synoptic Studies

Prior to 1964 it had been demonstrated that data from the MRN could be utilized on occasions for studying regional circulation patterns in the 30- to 60-km region. The large-scale motions of the lower stratosphere were found to extend up to at least the stratopause [68]. By the time of the IQSY, January 1964-December 1965, the frequency of rocketsonde observations had increased significantly and was adequate for quasi-synoptic analyses on at least a weekly basis. The area of analysis was primarily N. America and adjacent ocean areas, and

charts were prepared at the 5-, 2- and 0.4-mb levels, that is at 36-, 42- and 55-km altitude [69, 70]. In early 1965, the W. Geirinish site came into operation and provided the first extension to Europe at rocket heights. The weekly analyses have been continued for 1966 and 1967, and during 1966 rocket data from Arenosillo and Fort Sherman, and gun-probe data from Barbados permitted the area analysed to be further enlarged at the higher levels [71].

A regular feature of the summer months is a polar anticyclone which reaches peak intensity in July (late July in 1964, early July in 1967). Summer conditions are generally steady and symmetrical in longitude (Figure 1 [72]). Thereafter, the system decays slowly and by the end of August high latitude cyclonic activity may be expected to appear at 5 mb (36 km). As the cyclone cools, the anticyclonic circulation retreats southward reaching low latitudes by late October, so that most of the hemisphere is involved in an apparently steady nearly circumpolar westerly circulation. This situation is usually soon terminated by a warming with anticyclonic activity appearing over the Aleutian area, possibly before the end of October. A typical winter situation is difficult to define on account of the nonsteady conditions. The Aleutian anticyclone generally intensifies and displaces the polar low towards northern Europe or Eurasia. It may later fill in and subsequently intensify. When the temperature gradient between the high- and low-pressure systems increases, strong northerly winds develop over N. Canada (Figure 2).

The main changes that occur in the winter and early spring are associated with pulsations and displacements of the Aleutian high, and with the occurrence of stratospheric warmings (Section 2.4). The final phase occurs in late March or early April when a cyclone usually dominates the polar area again for a brief period before a warm polar anticyclone develops in response to springtime radiational heating. Up to 30 km, complete coverage in longitude has been provided for the N. Hemisphere since the IGY by high-level balloons; and daily and monthly mean charts are published by the Institute of Meteorology and Geophysics, Free University, Berlin. Synoptic studies by rockets are at present limited to N. America and adjacent ocean areas with occasional extensions to W. Europe.

IR sensing by satellites of CO_2 emissions in the 15 μ spectral region has more recently provided a new tool for synoptic studies in both the N. and S. Hemispheres. A single-channel radiometer in TIROS VII provided observational results over one seasonal cycle of the temperature field smoothed in altitude with maximum weighting at 20 km. Over 70 percent of the total received radiation originated at altitudes between 10 and 30 km [73]. The differences between the summer and winter synoptic situations were in general agreement with the above remarks based on rocket results. In terms of Fourier analysis of the temperature variance along high latitude circles, the winter observations showed a

predominance of wave number one and led to the conclusion that horizontal eddies were responsible for a considerable transport of ozone and heat in both hemispheres in winter; whereas in summer, wave number zero prevailed. On 14 April 1969, NIMBUS 3 was launched with an experiment to measure the outgoing earth radiance in seven channels of the 15 μ CO_2 band and one channel of the water vapour window. Synoptic charts have been prepared from this data for the 10-mb level and for lower levels where the additional channels operated [74]. With the launching of NIMBUS 4 on 8 April 1970, the technique was extended to about 45 km by the introduction of two "selectively chopped" channels which picked out line centres and allowed radiation from the higher levels to be detected [75]. Results from satellites are presented in the following sections.

2.1 N. Hemisphere Stratospheric Warmings

The development of unusually high temperatures (increases of as much as 70°C) in certain longitudinal regions of the stratosphere is a notable feature of winter and early spring at higher latitudes. Such warmings are observed to move downwards and polewards and have been known to extend over the whole polar region, causing a temporary reversal in the zonal circulation from westerly to easterly.

A survey of N. Hemisphere stratospheric warmings has been given by Kriester [76]. There are two general categories of warmings: midwinter warmings, which may be divided into minor and major warmings, and final warmings, which may be divided into early or late final warmings. A major stratospheric warming occurred in December 1967 which was unusual in that it began about one month earlier than previous early warmings [77].

Midwinter warmings in the N. Hemisphere in the first quarter of 1966 have been analysed by Labitzke at the 30- and 35-km levels where balloon observations are available at many longitudes [78]. The mean temperature differences between these two levels for January were in very good agreement with the CIRA 1965 differences. For February, however, when a major warming occurred, temperature differences as well as temperatures were longitudinally dependent, indicating a rapid change with height in the form of the longitudinal dependence. Such vertical structure is clearly apparent in the NIMBUS 4 observations with westward tilts of a few degrees longitude per km height [79]. Figure 3a relates to a layer approximately 20-km thick centred at 2 mb (42 km), and Figure 3b to a layer of similar thickness centred at 20 mb (26 km). The warm area over N. Siberia had intensified and moved northwards during the preceding week from latitude 25°N to the position shown for 4 January 1971. The difference in equivalent temperature near the 2-mb level between the hottest and coldest regions was more than 60°K. The pattern at the 20-mb level was similar, but the amplitude of wave number one was less and

the phase was about 25° farther eastward. This implies a westward tilt of the warm anomaly of 1.5° longitude per km height. Subsequently the warm region increased little in intensity, but moved westward. On 9 January 1971, the warm region had moved to 75°N 40°E with a westward slope of 3° longitude per km height; thereafter the warm region at the 2-mb level moved farther westwards and decayed in intensity.

Longitudinal variations in density are associated with those in temperature and may significantly affect the re-entry heating and dynamics of space vehicles [80]. For the December 1967 warming, horizontal density gradients in the arctic regions as large as 0.04 g/m^3/deg lat occurred at 40 km (typical density 3 g/m^3), corresponding to an increase in the normal latitude gradient by about a factor of three.

Strong winds are associated with stratospheric warmings as horizontal temperature gradients increase. The December 1967 event gave rise to a wind speed of 182 m/s at 47 km on December 13 at W. Geirinish. A year later at this site, on 7 December 1968, a speed of 184 m/s was observed at 55 km. The highest wind speed recorded in the stratosphere appears to be 198 m/s over Heiss Is. on 1 February 1966, which occurred at the relatively low height of 39 km [81].

The unpredictable nature of stratospheric warmings and the extreme conditions which can arise at these times add to the difficulty of deriving mean wind models with limited amounts of data, and of indicating the probability of deviations that may arise.

2.5 S. Hemisphere

For CIRA 1965 the following numbers of launchings at S. Hemisphere sites were available: Ascension Is. (8°S) 30, Woomera (31°S) 22 and McMurdo Sound (78°S) 14. At Woomera, the seasonal wind pattern appeared similar to that at 30°N sites judged by these few observations, which did not cover all months of the year. McMurdo Sound data were of interest because of the high latitude of this site, and from the few available winter observations it appeared that midwinter warmings of the Antarctic were similar in many respects to Arctic warmings, the circumpolar vortex tending to elongate and split [82]. The observations were not, however, sufficient to show whether the winter flow was disrupted in the S. Hemisphere to the same extent as in the N. Hemisphere.

At balloon heights, different S. Hemisphere winters have behaved in quite different ways in terms of the detailed temperature structure; but they have not shown the large-amplitude variability found in the Arctic [83]. In late winter (August and September) warm cells, principally in the Australian sector, produce perceptible perturbations in the otherwise zonal flow, which develop into the final warming.

Asymmetries in atmospheric heating and circulation between the two hemispheres may be expected to arise from the very different distributions of land and sea, although the effects in the stratosphere and mesosphere may not be large. Total ozone amounts, which were measured at 17 stations during the IGY, showed quite a distinct asymmetry: the maximum concentration in the S. Hemisphere occurring at 50 to 55° latitude throughout the year with decreasing concentration towards the pole, whereas in the N. Hemisphere the maximum occurred at 60° to 70° moving to above 80° during spring [84]. The upwards extension of such asymmetries has been uncertain due to the small number of S. Hemisphere observations.

Since 1966, new S. Hemisphere sites have operated in S. America at Natal (6°S), Chamical (30°S) and Mar Chiquita (38°S) as part of the EXAMETNET (Experimental InterAmerican Meteorological Rocket Network). Additional data have been obtained in Australia by falling sphere and parachute experiments at Woomera (31°S) and Carnarvon (25°S). In view of the large ocean areas in the S. Hemisphere, shipboard launchings have provided a means of extending coverage in latitude. Meteorological rocket launchings and pitot-static tube experiments were carried out from the USNS Croatan in April 1965 [85, 86], and 200 launchings have since been carried out from the USSR research vessels Voyeykov and Shokalsky [48]. Preliminary global charts of constant pressure height contours and wind vectors (Figure 4) have been drawn at the 2-mb and 0.4-mb levels. From these it has been concluded [48] that (i) the summer anticyclonic circulation is symmetric about the pole and is practically the same in both hemispheres, (ii) the winter circulation in the S. Hemisphere is less perturbed than in the N. Hemisphere, and (iii) during the transitional seasons (April and October) the two zonal flows are from the west. Point (ii) was supported by an analysis of Woomera data in comparison with CIRA 1965 [87]. It was concluded that the seasonal variation of the zonal wind between 35 and 75 km at Woomera was best modelled by a single sine wave with a wavelength of one year and that CIRA 1965 (based largely on N. American data and showing a more complicated winter variation) was less satisfactory. Subsequent to this analysis, the S. Hemisphere winter of 1969 was significantly different from the general pattern of winters in 1966, 1967 and 1968 showing a disturbance comparable with N. Hemisphere disturbances in high-level balloon data (up to 35 km) at Laverton (38°S, 145°E). Instead of maximum westerlies occurring in August 1969, the flow reversed, the zonal mean for August being easterly, and a return to weak westerlies followed before the summer pattern became established rather later than usual [88].

Antarctic stratospheric warmings have now been observed by satellite IR radiometry. TIROS VII was operational for the winter of 1963 and detected one midwinter minor warming and two later winter warmings, at latitudes of less than

60^o, which moved eastwards from Australia and the South Indian Ocean [89]. The S. Hemisphere winter of 1969 was observed by the polar-orbiting NIMBUS 3 up to the 30-mb (23 km) level [90]; a warm area developed in the Indian Ocean (Figure 5) and moved to the South Pacific Ocean during August passing south of Australia, where the decrease in westerly flow mentioned above was observed at balloon levels. This eastwards drift appears to have been shared by the temperature field over the whole S. Polar region. The low pressure area shown in Figure 5 remained fairly symmetrically located over the S. Pole from June to November when a final warming moved polewards from the Indian Ocean-South Pacific area. More pronounced changes in temperature were indicated, however, for higher levels and NIMBUS 4 has since provided this extension in height to the 2-mb (42 km) level for winter 1970 [75]. Figure 6a shows considerable structure in the pattern of isopleths at this level compared with the 20-mb (26 km) channel (Figure 6b).

2.6 Subtropical Ridge

At times of the year other than April and October, zonal flows are in opposite directions in the two hemispheres except at low latitudes where they merge along a subtropical ridge line in the winter hemisphere. Subtropical ridges are often shown on the N. Hemisphere synoptic analyses described in Section 2.3 and one appears in Figure 2 at about 20 to 30^o latitude for the 2-mb level. The associated anticyclonic activity provides a coupling system for the two zonal wind regimes. There are possibly three anticyclonic centres associated with each of the main oceans, the one in the Pacific extending further to the north than the others at the 2-mb level (42 km) (Figure 4). At the 0.4-mb level (55 km), the circumpolar winter circulation extends to lower latitudes and the high pressure areas are found nearer to the equator.

In terms of observations at individual sites, the hemispheric interaction is found to be located at lower latitudes at greater heights, in keeping with the foregoing remarks. At 55 and 60 km at Cape Kennedy (28^oN), a rapid decrease in westerly wind speed occurs in late November-early December followed by an increase in the late winter period (Figure 7a [91]). The values plotted in this figure are the monthly means based on 1961-66 (January and February) and 1961-65 (March-December) MRN data summaries. The effect appears also at lower stratospheric heights but the decrease is less rapid, the minimum wind speed being reached in mid-January (Figure 8a). At 55 and 60 km, the decrease is scarcely apparent at White Sands (32^oN) (Figure 7b) and has disappeared for Point Mugu (34^oN) (Figure 7c) and Wallops Is. (38^oN) (Figure 7d). At 30 and 40 km, however, there is evidence of a decrease at all these sites (Figure 8).

At Sonmiani (25^oN), the variation is similar to that at Cape Kennedy at 60 km but the winter westerlies are less intense and below 55 km the decrease in

December-January leads to a reversal to easterlies (Figure 9). According to Rahmatullah and Jafri, the stratospheric flow during the winter period is governed by a ridge of high pressure extending from N. Africa and Saudi Arabia to Indo-Pakistan and China. When the subtropical ridge is displaced southward due to deepening of the middle latitude trough, westerlies replace easterlies in the subtropics [92].

2.7 Quasi-biennial Oscillation (QBO)

The discovery of the QBO dates from 1960 when it was realised that the variations in equatorial zonal winds observed at low latitude during the 1950's were mainly cyclic, with a period of about 26 months [93]. Canton Is. (3^{o}S) data subsequently showed that the period underwent an increase from 21 months for the 1959-60 cycle to 30 months for the 1961-62 cycle. A period of 33 months is apparent in the cycle of 1963-65 (Figure 10) [94]. Long-period variations in the zonal wind have recently been studied on a global basis using 1950-64 balloon data from 200 stations [95]. The primary variation is the QBO of the equatorial stratosphere and its extension to higher latitudes.

The first observations of the QBO above 30 km were obtained from rocket soundings at Ascension Is. (8^{o}S), between October 1962 and October 1964 [96]. The zonal wind oscillation was found by Reed (i) to decrease in amplitude with increasing altitude above the 25-km level (where balloon data had shown an amplitude of about 18 m/s) and (ii) to propagate downwards in phase, as already observed at lower heights, but at a rate of 2 km/month, which is about twice the rate of propagation below 30 km.

The first two years of Ascension Is. rocket data were analysed also by Angeli and Korshover [97] along with zonal wind data for months between March 1960 and June 1964 from Cape Kennedy (28^{o}N), White Sands (32^{o}N), Wallops Is. (38^{o}N) and Fort Greely (64^{o}N). At temperate latitudes it appeared that (i) although amplitudes were small compared with the seasonal variation they increased with height so that above 55 km the QBO zonal wind oscillation was larger than at tropical latitudes, and (ii) the downwards propagation of phase was faster than at low latitudes, being 5 or more km/month.

Differences between the tropical and temperate parts of the oscillation have also been reported for the S. Hemisphere from an analysis of 1958-66 balloon data over Australia [98]. The maximum amplitude, which occurs at about 25 km in the tropics was not found in southern latitudes below 30.5 km, the effective altitude limit of observations.

A review of the QBO was presented by Rahmatullah at the Tenth COSPAR meeting [99]. At low latitudes, this component is responsible for a significant part of the zonal wind at stratospheric heights.

The presence of a QBO in other atmospheric parameters at low latitudes is not so apparent as in the zonal wind. For Ascension Is. ($8^{O}S$) densities taken between August 1964 and October 1966, a 26-month cycle was found to be significant (on the basis of the F-test) at the 5 percent level at 45 km where it reduced the variance by 7 percent, and at the 1 percent level at 30 and 35 km where it reduced the variance by 18 and 30 percent respectively; but no significant component was found at 40, 50 or 55 km [100].

2.8 Diurnal (Tidal) Variations Below 60 km

Since the preparation of CIRA 1965, the increased amount of data from meteorological rocket soundings has revealed the existence of diurnal tidal motions with amplitudes of several m/s. Diurnal components are more readily resolved in meridional winds than zonal winds, which are subject to large seasonal variations. Data from the summer months are most suitable for analysis as the circulation is then steadiest. At 50 km a diurnal amplitude of 8 m/s has been found using summer data over a number of years, the maximum south-to-north flow occurring close to local noon [101]. Diurnal amplitudes have also been obtained from multiple soundings within an interval of a day or so. A comparison between results obtained during a two-day observing period and the mean diurnal variation in summer, derived from the combined routine soundings at White Sands and Cape Kennedy, is shown in Figure 11. Diurnal variations in meridional flow have also been resolved at Ascension Is. ($8^{O}S$) and high latitude sites [102].

Although atmospheric tides have been investigated theoretically for over a century [103], no satisfactory account of the 24-hour component could be given until recently, as certain solutions of Laplace's tidal equation had been overlooked. The main thermal drives for the diurnal tide - insolation absorption by O_3 and H_2O - have been described by Lindzen [104] and the response of the atmosphere to given drives has been calculated. Figures 12 to 15 show the results obtained for the amplitudes and phases of the 24-hour wind components at the equinoxes below 100 km [104]. The large wind amplitudes near 100 km may not be realistic if the nonlinear terms in the equation of motion are significant. It is apparent that a complicated wind field is set up by relatively simple thermal drives. In practice the thermal drives may also have a detailed global distribution, particularly in relation to the water vapour distribution. The results are therefore a first approximation which may possibly be improved when the thermal drives are better known. At midlatitudes, the phase of the 24-hour tide changes rapidly with latitude and is therefore sensitive to the relative thermal input between low and high latitudes that is assumed. Seasonal changes in the thermal input will also have an effect.

Figures 16 and 17 show theoretical results obtained for the amplitude and phase of the 12-hour component in the northerly wind [103]. In view of the various uncertainties in the calculations, such predictions can be taken as no more than indicative of the general nature of the tidal oscillation generated.

Comparisons between the theoretical results and observed amplitudes and phases of the meridional wind component have now been made for various latitudes. Data analysed have been for the summer months (June-August), except for Ascension Is. where all published launchings were used irrespective of month (the seasonal effect at low latitudes being small). Figure 18 compares the observed amplitudes and phases for $8^{O}S$ (Ascension Is.), $20^{O}N$ (Barking Sands, Grand Turk and Antigua), $30^{O}N$ (Cape Kennedy and White Sands), $37^{O}N$ (Green River, Wallops Is. and Point Mugu) and $61^{O}N$ (Fort Greely and Fort Churchill) with the theoretical results. There is quite good agreement between theory and observation, particularly in view of the latitude sensitivity of the phase of the diurnal tide at midlatitude, which arises from the change from predominantly positive modes at low latitudes to predominantly negative modes at high latitudes.

In spite of the large seasonal trend in zonal winds, Reed et al. [105] have also obtained the amplitude and phase of the diurnal variation in the zonal component at $30^{O}N$ using Cape Kennedy and White Sands summer data. A comparison with the theoretical curve for the zonal winds is shown in Figure 18f and the general features are again in good agreement. Also shown in Figure 18f are the observed profiles for the meridional component (taken from Figure 18c). Except near 40 km, the phase difference between the two components is about 90^{O} corresponding to a clockwise rotation of the wind vector with time.

Seasonal variations in tidal components have been investigated for $31.5^{O}N$ using two-monthly groupings of data [106, 107]. Quite significant variations of phase with season occur particularly in the diurnal component where phases may change rapidly with height (Figures 19 to 22). Although progress has been made in resolving diurnal and semi-diurnal components at meteorological rocket heights, the results outlined above are either restricted to $30^{O}N$ latitude or to summer in the case of other latitudes. As more data accumulate with each year of observation, the possibility of extending the analysis to other seasons and latitudes increases.

A number of attempts have now been made to observe diurnal variations in stratosphere temperatures [108], but the amplitudes obtained have been consistently greater than those predicted by tidal theory in spite of considerable efforts to eliminate possible instrumental effects. Observed amplitudes for 30^{O} latitude (Figure 23) are subject to a great deal of scatter, but at 48 km a value close to $8^{O}K$ is indicated. A limited sample of rocketsonde temperature and wind data gathered during a series of launchings at Wallops Is. suggests that the diurnal

range of observed temperature consists of components that can be ascribed to (i) the real diurnal variation, and (ii) radiational error of the rocketsonde instrument [111]. At 50 km and below, many temperature observations have been provided by MRN launchings which mostly take place close to local noon. For this reason the CIRA 1965 temperature models were biassed to local noon conditions. A comparison [1] showed MRN temperatures at 30° latitude to be higher than grenade experiment temperatures, which were not so biassed, by 8°K at 40 km and 6°K at 50 km. In preparing the temperature models presented below, an attempt was made to remove diurnal components by the same process of averaging over local time as used for the W-E winds. However, in this case insufficient nighttime data were available to produce any effective change, and the only practical course was to ignore local time in constructing the temperature models and recognise that, like the earlier CIRA 1965 temperature models, they are biassed towards noon conditions at 50 km and below.

Corresponding diurnal dependences will also be present in pressures and densities. Diurnal variations derived from temperatures measured during multiple MRN launchings at White Sands (32°N) in 1965 have given an amplitude of 4 to 7 percent in pressure and 3 to 5 percent in density for the 52-58 km layer [114]. Diurnal density variations derived in the same way from multiple launchings at Ascension Is. (8°S) have shown an amplitude of 4 percent at 50 km [100]. Although these variations are small, they are comparable with the seasonal variation at latitudes of less than 30°.

2.9 Meridional Flow Below 60 km

The synoptic analyses discussed in Section 2.4 show that large S-N wind speeds may arise at times which are comparable with W-E wind speeds. Such occurrences are usually at mid- or high-latitudes during wintertime. At other times, meridional wind velocities are generally small compared with zonal velocities and consequently their seasonal pattern is not so readily apparent as that for the zonal winds.

Figure 24 shows S-N wind components up to 55 to 60 km for the period from October to December 1966 at two sites, Wallops Is. and Arenosillo, which are nearly at the same latitude but differ by 70° in longitude [115]. Wind magnitudes differ appreciably between the two sites at a given time and may even be of opposite sign. Also, changes in magnitude occur at a particular site within one or two weeks which are of a similar order.

A distinction can be made between transient eddies, which give rise to time variations in the meridional wind at a particular site and standing eddies which are related to the longitudinal variations in the time-averaged value. When evaluated for the troposphere (in terms of the appropriate standard deviations),

both transient and standing eddies were found by Newell, Wallace and Mahoney [116] to be largest in the vicinity of the midlatitude jet stream at 10-km altitude. The standing eddies are smaller in summer than winter, and even in winter their standard deviations are small in comparison with those of the transient eddies, which show little seasonal change (and have a maximum standard deviation of 15 m/s).

The mean meridional circulation, in the form of cellular motion in the vertical plane, is difficult to obtain without large quantities of globally distributed data on account of the presence of eddies. Evaluation is required of the mean standing eddy velocity around latitude circles and has so far been limited to balloon altitudes. In the lower stratosphere, mean meridional motions and standing eddies have been derived from IGY data up to the 30-mb level (24 km) [117]. During October to December 1957, the flow was southwards over Canada and Greenland with velocities up to 10 m/s and was northwards over E. Asia (Figure 25). During January to March 1958, a second cell was present over W. and Central Asia. By late spring speeds had slackened and by late summer, there was polewards flow north of 60° latitude at 1 m/s or less. On averaging round a circle of latitude, considerable cancellation occurred and values for the zonally averaged meridional flow were found to be similar for both the winter and summer months (Figure 26). Mean speeds were generally less than $\frac{1}{2}$ m/s, and the flow direction was polewards at latitudes greater than 60° and equatorwards at latitudes less than 60° throughout the lower stratosphere, that is from 17 to 24 km.

Transient eddies in the lower stratosphere tend to increase with latitude, and values of the order of 10 m/s were found in the above study at high latitudes. Polewards of 30° latitude, a seasonal variation in the transient eddy velocity was present. With regard to height dependence, transient eddies were least in the region of 24 km.

Above 24 km, the longitudinal coverage by balloon observations has been inadequate for zonal averaging and analysis of standing eddies and the meridional circulation. Temporal standard deviations may nevertheless be evaluated for a limited longitudinal distribution of sites using balloon data (to 30 km) and meteorological rocketsonde data (to 60 to 65 km). Above the transient eddy minimum at 24 km, values were found to increase to a maximum at 50 km or more and to reach 25 m/s at high latitude in winter [116]. Seasonal dependence is prominent in stratospheric transient eddies in comparison with the tropospheric ones, possibly due to the seasonal reversal of the stratospheric vortex.

Standing eddies are expected to be an important feature of the circulation at rocket heights as well as at balloon heights. Above 24 km, the presence of standing eddies has been indicated in winter by the high values (~ 10 m/s) of the time-averaged meridional velocities obtained from rocket launchings over N. America [116].

A more detailed analysis of these parameters of meridional flow awaits a better global distribution of data.

2.10 Seasonal Variations Below 60 km

Seasonal variations are one of the main variations of stratospheric and mesospheric structure, and have already been referred to in Sections 2.3, 2.5, 2.6 and 2.7.

Rocket observations since CIRA 1965 have provided data at new locations, particularly at low latitude and in the S. Hemisphere. Figure 27 shows a latitude-time section of the zonal wind at 40 km for 1961-68 [118]. At mid- and high-latitudes, there is the well-established pattern of easterlies in summer and stronger westerlies in winter. The easterlies recur very regularly each year, but the westerlies show year-to-year variations in the winter and early spring. Figure 28 shows the seasonal variation of the standard deviation of the zonal wind about the monthly mean for Fort Greely (64^{o}N) [91]. Variations are much greater in the winter than the summer and values close to 25 m/s are reached. It may be recalled that 25 m/s was the value reported for the N-S transient eddy standard deviation at high latitudes in winter (Section 2.9).

At low latitudes, the summertime easterlies at 40 km (Figure 27) extend across the equator into the winter hemisphere, giving rise to a semi-annual variation. Due to the presence of the QBO, the annual cycles are significantly modified. The semi-annual variation was quite well represented by the CIRA 1965 W-E wind model, considering the small amount of low-latitude data then available. Figure 27 shows how many more low-latitude data are now available than at the end of 1963.

Using data from Ascension Is. and other sites up to September 1964, Reed [119] estimated a maximum amplitude for the semi-annual variation of 30 m/s near 50 km, and located the core of the summer easterlies at 15^{o} latitude. The levels of maximum easterlies at several low-latitude sites have been studied by Rao and Joseph [120]; and the structure of the semi-annual variation at different longitudes has been investigated by Quiroz and Miller [121].

Figure 27 shows that easterlies from the S. Hemisphere penetrate further into the N. Hemisphere than do N. Hemisphere easterlies into the S. Hemisphere; that is, there is a seasonal asymmetry between the N. and S. Hemispheres. The S. Hemisphere westerlies extend further towards the equator than the N. Hemisphere westerlies is part of the same asymmetry. Although data are lacking at mid- and high-latitude in the S. Hemisphere, both winter and summer regimes in the S. Hemisphere appear to be more intense or more extensive in latitude than their N. Hemisphere counterparts.

A hemispheric asymmetry also appears in temperature data at maximum balloon altitudes. Differences of up to 15^{o}K have been reported [122] for the same

season in opposite hemispheres; but annual means differ by only 2 to 3°K between the two hemispheres for the same latitude. As with the CIRA 1965 temperature models, S. Hemisphere rocket temperature data are at present too few for separate consideration of the two hemispheres over a wide range of latitude. The new models presented below are representative of the N. Hemisphere at longitudes 70° to 160°W for heights of 25 to 55 km.

3. ATMOSPHERIC STRUCTURE 60 TO 120 KM

3.1 Introduction

When the CIRA 1965 models were prepared, rocket experiments had provided just a handful of wind and temperature observations above 60 km. The number of launchings at different sites, most of which had been grenade experiments, were as follows: Woomera (31°S) 22, Wallops Is. (38°N) 19, Fort Churchill (59°N) 15, Guam (13°N) 9, Akita, Japan (40°N) 6 and Kronogård, Sweden (66°N) 3.

During the last six years, data have been obtained by grenade experiments at a number of new sites: Point Barrow (71°N), ESRANGE (68°N), Arenosillo (37°N), Sonmiani (25°N), Natal (6°S) and Ascension Is. (8°S). Other new sites giving profiles to 80-km altitude have been Heiss Is. (80°N) and Volgograd (49°N) [123]. Falling-sphere experiments have been another useful source of data at heights which sometimes extend to 115 km. Techniques for mesospheric sounding have been reviewed in references [124] and [125]. Ground-based methods, particularly the radio-meteor technique, have provided wind data at 90 ± 10 km altitude, filling in nicely between the upper height limit for grenade data and the lower height limit for chemical trails; these have become an important source of lower-thermosphere wind data in recent years.

The new CIRA models nevertheless suffer from some of the same limitations as CIRA 1965 above 60 km:

(i) It has been necessary to combine observations from all longitudes without consideration of longitudinal effects. Most data are from N. American sites, and so any longitudinal bias would be towards the W. Hemisphere.

(ii) Insufficient S. Hemisphere data have been available for developing a separate model. Therefore, S. Hemisphere data have been combined with N. Hemisphere data with a six-month change of date.

(iii) Due to insufficient data, no account has been taken of local time in development of the temperature models. Consequently, pressure and density models may also be diurnally biassed.

(iv) In development of the wind models, an attempt was made to remove diurnal effects by an averaging process based on local time but absence of data

during certain times of the day, for example with chemical trail data, is a fundamental limitation. In the case of radio-meteor wind results, diurnal components are satisfactorily removed by harmonic analysis.

The new models, therefore, give a seasonal-latitudinal representation of atmospheric structure, extending to greater heights than CIRA 1965. The temperature, pressure and density models extend to 110 km and the new zonal wind models to 115 km at most latitudes. At lower heights, the models should be more representative of mean conditions now that a greater number of observations is at hand.

3.2 Measuring Techniques

3.2.1 FALLING-SPHERE METHODS

The main requirements for a meteorological rocket system are quick data readout, simple field operations, all-weather operation and low cost. Although these requirements can be fairly closely met below 60 km, no comparable technique is available at greater heights. Considerable experience has been gained with passive falling spheres [126] which have been considered for network operations on account of their simplicity, reliability and cost effectiveness, but in practice their use has been limited to those sites where high-precision radar facilities are already available. On the other hand, the use of falling-spheres instrumented with accelerometers simplifies ground-equipment requirements, but increases payload costs considerably. Density data to 90 to 110 km have been obtained by both passive and instrumented falling-spheres, and in special cases, for example high apogee flights, to slightly greater heights. Temperatures and pressures are normally derived from the density profile. The main sources of error in sphere density measurements are (i) inaccuracy in measuring the accelerations, and (ii) uncertainty in the drag coefficient particularly in the transonic regime. Representative errors have been summarised as follows [12]:

Robin (1 m diameter): 3 to 3.5% (40 to 70 km) for FPS-16 radar, rigid sphere and optimum curve fitting.

Inflatable metallized sphere (2 m, WRE Australia): Subsonic region: 6% (70 km) decreasing to 2% (40 km) if vertical motion is zero; 6% (70 km) decreasing to 4% (56 km) increasing to 8% (40 km) for 2 m/s vertical motion. Supersonic region: 10% (97 km) due to errors in measurement of accelerations with an error ≥5% in drag coefficient.

Rigid sphere (66 cm) with accelerometer: 5% (30 to 105 km) except at Mach 1 near 70 km; 10% (105 to 120 km) with best radar data.

Wind data are usually obtained over a range of heights (up to 70 km) in which the rate of fall of the sphere is sufficiently reduced to make it wind sensitive.

3.2.2 THE GRENADE METHOD

Another main rocket technique for atmospheric sounding is the grenade method, in which temperatures and winds are calculated from the travel times of sound waves generated by grenades exploded in sequence after ejection from a rocket on the upleg of its flight path. Although complexity of data reduction and cost have limited the scale of operations, an approach has been made with this technique to synoptic-type observations over N. America, particularly during the midwinter period [127]. Acoustical detection is generally possible to 90-km altitude. Wind and temperature determinations are effectively averaged over layers a few km thick depending on the vertical separation of the grenade explosions. The accuracy with which such data have been obtained at N. American sites has been estimated from the errors in each recorded parameter. Figure 29 shows computed errors in temperature. Prior to mid-1965, the basic size of the Wallops Is. microphone array was about 2,000 feet before being increased to about 30,000 feet with marked reduction in error. Since the temperature results are layer averages, the errors at discrete heights may be larger than the values in Figure 29.

3.2.3 PRESSURE GAUGE METHODS

Pressure gauges have been used extensively in Soviet meteorological rocket soundings with at least two types of rocket for altitudes up to 50 km and 90 km, respectively [128]. Pirani gauges are mounted on a forward-pointing probe together with tungsten-wire thermometers for determination of wall-temperatures. Measurements are made on both the ascent of the rocket and the descent of the instrument nose cone by parachute. A complicated analysis, involving vehicle Mach number and mean free-path length, enables both ambient pressure and temperature to be deduced. Errors (rms) in temperature are stated as $2^{o}C$ below 30 km, $3^{o}C$ at 40 km, $8^{o}C$ at 50 km and $12^{o}C$ at 70 km. The rms error in pressure is given as 4 percent. Results have been obtained to 80-km altitude.

In USA launchings, interest in the use of pressure gauges has related to measurements above 90 km, where observations are few and techniques are difficult to apply. Gauges have been of the ionization type with a radioactive ionization source and wide range of operation. Conditions of free molecular flow prevail at these heights, and from the stagnation pressure at the nose tip ambient density can be derived if vehicle velocity and angle of attack are known. Rocket vehicles, therefore, need to be instrumented for attitude sensing and DOVAP (Doppler velocity and position determination). Below 90 km, in the region of continuous flow, ambient density can be derived from the basic pitot tube equation. With present techniques, the total range of density measurement is from 40 to

120-km altitude. Below 90 km, ambient pressure can also be measured directly at the static-pressure point of the nose probe (a pitot-static tube), and temperatures can be calculated from the density profile. A comparison between pitot-tube, grenade and thermistor temperatures is shown in Figure 30. Above 50 km, there is good agreement between the pitot-tube and grenade experiments, while below this height the thermistor temperatures agree favourably with the grenade temperatures [127].

3.2.4 CHEMICAL RELEASES

Above 90 km, rocket techniques for wind measurement mostly employ chemical releases in the form of either trails of sodium or TMA (trimethyl aluminium) or clouds produced by small amounts of explosive [129, 130]. Wind speeds are obtained by optical tracking of the releases over a time interval of 1 to 5 minutes, and wind errors are usually in the range of 1 to 10 m/s according to the altitude.

Sodium trails are observed by resonance radiation from the sun and, therefore, only yield results at morning or evening twilight when they can be observed against a dark sky background. On the other hand, aluminised trails or clouds are chemi-luminescent through reactions between aluminium oxide (AlO) and atmospheric atomic oxygen and offer the important advantage of nighttime observation, when wind determination is usually possible from 90- to about 150-km altitude. The sodium trail technique was first employed in 1954 and TMA releases were introduced in 1963. The rocket-borne equipment for these releases is relatively simple, and experimental groups in many countries have undertaken them at an early stage of their work on investigating the upper atmosphere. In recent years, low-latitude data have become available from sites at Thumba (9°N) [131] and at Barbados (13°N) where winds have been measured to 140 km using gun-launched probes [132]. A similar gun facility was brought into operation at Yuma, Arizona (33°N) in June 1966. At latitudes greater than 40°, there is still an almost complete lack of wind data above 100 km. It is at midlatitude sites that most experiments have been conducted, yet even here the prevailing wind patterns are difficult to ascertain due to the presence of diurnal and other short-term variations of similar magnitude, the absence of daytime data and the infrequency of observations at other local times.

Other techniques employing chemical releases enable ambient temperatures to be determined spectroscopically at twilight and ambient densities to be derived from diffusion rates, but these techniques are generally only effective above 120 km.

3.2.5 GROUND-BASED METHODS

Although the radio-meteor method dates back to 1953 when it was first employed at Jodrell Bank (53°N) and at Adelaide (35°S), it is only in recent years

that attention has been given to its introduction at other sites and its possible value for synoptic investigations. Wind speed components are determined from the line-of-sight velocities of a number of meteor ionization trails measured by the Doppler shifting of reflected radio signals. For the Adelaide system, the accuracy of the line-of-sight drift is generally better than 10 percent of the drift speed; that is, ±3 m/s for an average trail [133]. Other errors such as those in echo range (~±2 km) and zenith angle (less than 1°) may, however, be at least as important [134].

An advantage of the radio-meteor method over rocket techniques is its continuous-sampling capability, leading to the resolution of tidal and prevailing components. As tidal and other short-term variations account for a significant part of the total wind vector above 75 km, radio-meteor results provide a valuable source of data on prevailing winds and have been combined with rocket results in devising the new W-E seasonal wind model.

Results or E-region drifts have not been utilised in view of the uncertainty of their interpretation as winds and the variability of the reflection height. In the case of ionospheric drift measurements at low radio frequencies, an interpretation in terms of real winds is justified. The reflection height is about 95 km at night, observations being restricted to night hours by the strong daytime absorption in the LF range. Such results are available from Kühlungsborn and Collm in the German Democratic Republic.

3.3 Data Available

3. 3. 1 WIND DATA

Table 4 summarises wind data from rocket and gun-probe techniques at heights from 60 to 130 km that were utilized in preparing the new W-E wind models. These models were obtained by updating a similar set of models developed in 1968 [155]. Only minor changes were introduced as a result of an additional two years of data. Wind sensors in use have been either parachutes, spheres or chaff and most of the data obtained in this way have been at the lower heights (60 and 65 km) with observations to 75 or 80 km at a few sites. Acoustical propagation from grenade detonations has provided results to about 90 km. Above 90 km, results have been obtained by optical tracking of chemical releases. An important source of data in the 95-km region has been provided by ground-based methods, particularly the radio-meteor method (Table 5).

3. 3. 2 TEMPERATURE DATA

Table 6 lists the data that have been utilized in preparing the new temperature models. The analysis was undertaken in 1969. Several sites at low- and mid-latitudes have contributed data, but at high latitudes the models depend on

Fort Churchill and Point Barrow only and were not extended beyond 70^{o}N. Heiss Island data were used to prepare a separate 80^{o}N model (Table 22).

3.4 N. Hemisphere Synoptic Studies

Synoptic studies by rockets have so far been limited to heights below 60 km on account of the complexity and cost of present techniques. The introduction of radio-meteor wind measurements at an increasing number of new sites is, however, beginning to change this situation, at least for the 90 to 95 km height region. Figure 31 has been drawn for January data from meteor trails, ionospheric drifts and rockets [48]. The 0.001-mb contours are spaced by calculation from the gradient wind equation, and absolute values are taken from rocket data. With the co-ordinated operation of radio-meteor stations on a regularly scheduled basis, more results of this nature should be forthcoming. Any conclusions from Figure 31 can only be tentative but wintertime cyclonic circulation is seen to extend upwards to these levels, with a general decrease in westerly wind speeds due to the reversal of the latitudinal temperature gradient above 65 km. The slight asymmetry in the vortex may also be an upwards extension of the well-defined asymmetries at lower heights.

3.5 Possible Solar-cycle Dependence

The need for extended observations of upper mesosphere/lower thermosphere conditions is emphasized by recent evidence of a possible solar-cycle effect. Figure 32 shows wintertime winds (November to February) measured at Kühlungsborn (54^{o}N, 12^{o}E) and Collm (51^{o}N, 13^{o}E) at various parts of the solar cycle. The prevailing zonal component increased with increasing solar activity from about 15 m/s towards the E. at solar minimum to nearly 40 m/s towards the E. at solar maximum [173]. Other components also appear to have been affected.

At other sites, operations have not yet continued over an adequate interval of time for possible long-term effects to be resolved. Consequently, there has been no alternative but to ignore this dependence in preparing the new models. The results from Kühlungsborn and Collm indicate quite a considerable effect, but further results are needed. A comparison with the new W-E wind models shows that the latter correspond to conditions at the time of the last solar minimum. This is reasonable as much of the available 50^{o}N latitude data was obtained during the IQSY.

Evidence of a possible solar-cycle dependence in other atmospheric parameters has also been cited. Winter temperatures at 80 km at Fort Churchill (59^{o}N) show an average decrease of about 30^{o}K between solar maximum and

solar minimum, and summer temperatures show a possible small decrease as well [174]. Meteor counting rates [175] and falling-sphere densities [176] have also been analysed showing a solar-cycle effect at mesospheric heights.

3.6 Diurnal (Tidal) Variations

Above 60 km, tidal variations have been most extensively observed in wind components by the radar-meteor method. The 24-, 12- and 8-hour solar components are usually extracted by harmonic analysis. Amplitudes and phases can be expected from theoretical considerations to be both latitudinally and seasonally dependent. Also there is evidence of long-term variations, apparently related to the solar cycle, in periodic as well as prevailing components (Figure 32). For these reasons, the present data coverage is still too fragmentary for a global presentation of tidal patterns. In addition, the height coverage by the radar-meteor method is limited to about 90 ± 10 km and in many cases the observations are analysed for a mean height of 95 km.

At latitudes 50 to 55°N where several stations are now in operation, the 12-hour component is found to be the main periodic variation exceeding the 24-hour component by a factor of 3 to 4. In contrast to the 24-hour component, seasonal changes in the 12-hour component follow a regular pattern. For most of the year, the phase of the W-E component leads that of the S-N component by about 3 hours, corresponding to a clockwise rotation of the wind vector. According to tidal theory, maximum northward flow would occur at about 5 hours local solar time at the equinoxes at 95 km, and the yearly averages for Sheffield (0442 hours) and Kharkov (0509 hours) are found to be in close correspondence [163]. In the September-November period, an abrupt change of phase usually takes place; in 1965 the phase advanced by 9 hours in an interval of 3 weeks [164]. Figure 33 summarises in an idealised way the seasonal distribution of the 12-hour tidal winds for latitudes close to 50°N.

In 1967-68 at Molodezhnaya (67°S), the amplitudes of the 12-hour component were, in the main, greater than those of the 24- and 8-hour harmonics and showed other similarities with N. Hemisphere data. The phase difference between the EW and NS 12-hour components was 3 ± 1 hour for most of the year (but with anti-clockwise instead of clockwise rotation), and an abrupt change of phase occurred in the autumn [177]. At Heiss Is. (81°N), both 24- and 12-hour components have been of comparable magnitude and equal to 10 to 20 m/s, their vectors rotating clockwise [177]. At Adelaide (35°S), the amplitude of the 24-hour component is greater than at higher latitude sites and is comparable with the 12-hour component. Contributions from the principal positive diurnal mode can be expected to be significant at this latitude and to introduce a rotation of the 24-hour component wind vector with height as well as time. Particular attention has been given to height

resolution in the range 80 to 100 km in the analysis of observations from the Adelaide site [156]. Results for the 24- and 12-hour components observed during 1966-69 are shown in Figures 34 to 37 [157]. Results for 90 km have shown a satisfactory comparison with the theoretical diurnal tide at the equinoxes (Figures 12 to 15) when due regard is taken of the simple model for the thermal drive upon which the theory is based [108].

Above 90 km, tidal period winds have been sought by analysis of data from chemical releases. The absence of data during daytime and of adequate samples of data in general are limiting factors. An analysis of 29 twilight trails from sites at 38°N apparently resolved a significant 24-hour component from 90 to 130 km and provided evidence of rapid energy dissipation of this harmonic above 105 km [178]. Dissipation of both the 24-hour and 12-hour components in this height range has been evidenced by an analysis of 42 rocket releases at Eglin (30°N) [179]. In spite of the attenuation of the upward tidal energy flux, the decrease of ambient density with height tends to maintain velocity amplitudes so that tidal components still contribute significantly to the total wind vector.

Above 130 km, data samples have so far been inadequate for resolving harmonic components. An alternative approach has, therefore, been the examination of the altitude variation of wind profiles for large-scale vertical wavelengths and the identification of these with particular tidal modes. Higher-order, semidiurnal modes appear to dominate in the 120- to 160-km region, although an adequate tidal theory is not yet available for justifying such identifications [180].

3.7 Seasonal Variations and Atmospheric Circulation Above 60 km

Seasonal variations are one of the main variations of atmospheric structure in the stratosphere and mesosphere, and have been referred to in Section 2.10 for heights below 60 km. In CIRA 1965 [1] the seasonal variation was presented (with monthly values) to 80 km. Relatively few observations of densities or temperatures are available in the lower thermosphere below satellite heights. Therefore in the U.S. Standard Atmosphere Supplements, 1966 [181], curve-fitting techniques were used to join seasonally-dependent, lower-thermosphere density profiles with nonseasonal models calculated for greater heights. At 90 km, seasonal variations of density are found to be relatively small, yet the seasonal temperature variation is large. Therefore a rapid increase in the amplitude of the seasonal density variation between 90 and say 100 to 120 km is implied by hydrostatics. On the other hand, a correspondingly rapid decrease in the seasonal density variation is indicated above this region by the apparent lack of a seasonal variation at the lower satellite orbiting heights (160 km).

The well-known seasonal reversal in stratospheric and mesospheric zonal circulation at midlatitudes (easterlies in summer and stronger westerlies in

winter) is the main feature of the CIRA 1965 W-E wind models. Chemical trail releases and ground-based techniques have now provided new data above the 80-km level. In 1964, zonal wind patterns for January and July were extended to 120 km for latitudes up to 75°N using Adelaide radio-meteor results and chemical release data from Wallops Is., Eglin AFB and Woomera, Australia [182]. In 1969, this model was updated at low latitudes on the basis of the wind results from the Barbados gun-launched probes (Figure 38) [183]. Although equatorial winds appear to be from the east at heights of 95 ± 15 km throughout the year, a slight shifting of the wind belt N. and S. of the equator results in a seasonal reversal being observed at the latitude of Barbados [155].

Mean latitudinal cross sections of zonal winds were developed in 1965 [184] for both the equinoxes and solstices using data obtained by the radio-meteor and E-layer drift techniques. In summer the easterlies changed to westerlies in the E-layer, and above 120 km a return to easterlies was thought to be indicated by sodium trail data. This description agrees with the July half of Figure 38, but in winter the westerlies were taken to extend to only 100 to 110 km before reversing to easterlies, whereas the January half of Figure 38 shows them extending to 120 km. The dashed lines in Figure 38 indicate the regions where data have been scant or nonexistent. These uncertainties in the zonal flow above 100 km largely remain today, particularly polewards of 40° latitude.

In the stratosphere and mesosphere, meridional circulation is more difficult to analyse observationally than zonal circulation on account of the smaller flow velocities involved. In the upper mesosphere/lower thermosphere, however, meridional components are often observed which equal or exceed zonal components. Tidal components contribute significantly at these heights to both zonal and meridional components but, even when these have been extracted, as with the radar-meteor technique, prevailing meridional velocities of the order of tens of m/s remain. Figure 39 shows the meridional components obtained from an analysis of data from rocket, gun-probe and ground-based techniques. A prominent feature of Figure 39 is the flow from the summer hemisphere to the winter hemisphere at 85 to 105 km; that is, at heights accessible for observation by the radar-meteor technique. Figure 40 shows such observations for individual stations, and the seasonal variation stands out quite clearly. Observations are, however, needed at other longitudes to obtain the zonally-averaged meridional flow. Cancellation would be expected to occur on averaging round a circle of latitude, due to the presence of standing eddies, as found at lower heights (Section 2.9).

4. MODELS OF W-E WIND, TEMPERATURE, PRESSURE AND DENSITY

4.1 W-E Wind Models

4.1.1 INTRODUCTION

The W-E wind is expressed as

$$u = u_o + u_1 + u_2 + u_{QB} \tag{1}$$

where u_o is a seasonal component, u_1 and u_2 are the 24- and 12-hour tidal components and u_{QB} is the so-called quasi-biennial oscillation. Each of these components exceeds 20 m/s at some height or latitude. Other components have not been included either because they are much smaller, for example the 8-hour tidal component, or because they are not yet well-defined, for example there may be a long-term variation at upper-mesospheric heights which is associated with the solar cycle (Section 3.5).

4.1.2 SEASONAL MODELS, u_o

Figure 41 shows meridional cross sections of W-E winds for the first day of each month and latitudes 80°N to 80°S. Up to 60 km, the S. Hemisphere model is based on S. Hemisphere data where available and is blank in regions where no data are available. Above 60 km, data coverage is poor in the S. Hemisphere, and the model shown is that for the N. Hemisphere with a 6-month change of date. Obviously if hemispherical differences are present below 60 km, they do not suddenly disappear at this level, and the contour patterns below 60 km are to some extent indicative of conditions above 60 km.

For the winter months, realistic models are difficult to devise on account of longitudinal asymmetries. Two separate models have therefore been developed below 60 km from (i) N. American data, and (ii) European/W. Asian data for the months October to April. A comparison between the two models underlines the difficulty of finding representative values. For the other five months of the year, longitudinal asymmetry is relatively small. The wintertime asymmetries can be expected to extend above 60 km, but a poor distribution of data in longitude prevents a detailed analysis. No analysis of longitudinal effects has been possible for the S. Hemisphere at any height, but there is evidence that the wintertime stratospheric circulation in the S. Hemisphere is less perturbed than that in the N. Hemisphere (Section 2.5).

The tabulated values on which Figure 41 is based appear in the following tables:

Tables 7 a and b - West-East winds (m/s), 26 to 60 km: based on N. Hemisphere data from all longitudes except for sites north of 25°N where, between mid-September and mid-April, only data from N. America are included.

Tables 8 a and b - West-East winds (m/s), 25 to 60 km: based on N. Hemisphere data from all longitudes except for sites north of 25°N where, between mid-September and mid-April, only data from Europe/W. Asia are included.

Tables 9 a and b - West-East winds (m/s), 25 to 60 km: based on S. Hemisphere data from all longitudes.

Tables 10 a and b - West-East winds (m/s), 60 to 130 km: based on data from all longitudes with S. Hemisphere data shifted 6 months in time.

An account of the method of preparation of Tables 7 to 10 is given in Appendix A.

4.1.3 THE QUASI-BIENNIAL OSCILLATION IN W-E WINDS, u_{QB}

Along with the preparation of the seasonal models (Section 4.1.2), W-E wind data below 60 km from individual sites were analysed for a periodic component of unknown period T in the range 24 to 40 months. When determined, the component was subtracted from individual profiles and an improved seasonal model obtained. The computation was then recycled by removing the seasonal component from individual profiles and improving the determination of the quasi-biennial component. The analytical form taken was

$$u_{QB} = A \cos[2\pi(M - M_o)/T] \tag{2}$$

where M is time after 1 January 1966 in units of months, and M_o is a value of M when maximum flow from the west occurs. The quantities A and M_o depend on latitude and height.

The component u_{QB} was resolved for the following stations or combination of stations: Ascension Is. (8°S); Gan (1°S) + Natal (6° S); Fort Sherman (9°N); Antigua (17°N); Grand Turk (21°N) + Barking Sands (22°N); Cape Kennedy (28°N); Point Mugu (34°N); White Sands (32°N); Tonopah (38°N) + Wallops Island (38°N); Volgograd (49°N) + Primrose Lake (55°N); Fort Churchill (59°N); Fort Greely (64°N); Thule (77°N). The results obtained showed that:

(i) A value of T equal to 32 months was appropriate to all stations for minimizing the sum of residuals squared.

(ii) Amplitudes were small (generally less than 5 m/s) at latitudes greater than 20°.

(iii) A high degree of symmetry about the equator was indicated by a comparison between the Ascension Is. (8^{o}S) and Fort Sherman (9^{o}N) results.

Values of A and M_o, which are consistent with those for the individual stations, appear in the following tables:

Table 11 - Amplitude A (m/s) of the QBO of the W-E wind (T = 32 months).

Table 12 - Number of months after 1 January 1966 M_o when maximum flow from the west occurs in the QBO of the W-E wind (T = 32 months).

Equation (2) is only valid for those years over which data are available and should not be extrapolated to other dates; it is expected to be valid for 1961-69. The period of 32 months is consistent with Figure 10 for 1961 onwards. Prior to 1961 changes occurred in the QBO period as discussed in Section 2.7, and there is no reason to doubt that such changes may occur at a future date.

4.1.4 24- AND 12-HOUR COMPONENTS, u_1 AND u_2

For these components, write

$$u_1 = A_1 \cos \pi(t - t_1)/12$$

$$u_2 = A_2 \cos \pi(t - t_2)/6 \qquad (3)$$

where t is local time in hours and t_1, t_2 are the times of maximum flow from the west. Information concerning A_1, A_2 and t_1, t_2 is rather fragmentary:

Below 60 km:

(i) A_1, A_2 are less than 10 m/s at all latitudes and seasons.

(ii) For 30°N in summer, values of A_1 and t_1 are shown in Figure 18f from observation and theory.

(iii) For other latitudes at the equinoxes, theoretical values of A_1 and t_1 are shown in Figures 12 and 13.

(iv) For 31.5°N, observational values of A_1, t_1 and A_2, t_2 are shown in Figures 19 and 20 at two-monthly intervals.

Above 60 km:

(i) For various latitudes at the equinoxes, theoretical values of A_1 and t_1 are shown in Figures 12 and 13.

(ii) For 35°S, observational values of A_1, t_1 and A_2, t_2 for 1966-69 are shown in Figures 34 to 37.

(iii) For 50°N, A_2, t_2 at 95 km show a regular seasonal trend (changing abruptly in September-November) which is illustrated in Figure 33. A_1 is generally less than A_2 and is subject to interdiurnal variations, but for long-term averages (year 1964-65) $\bar{A}_1 \sim 6$ m/s, $\bar{t}_1 \sim 14$ hours [163].

4.1.5 COMPARISONS OF W-E WIND DATA WITH THE SEASONAL MODELS

The results of comparison between individual wind profiles and the models (Tables 7 to 10) are shown in Tables 13 to 17 respectively. The information tabulated for each monthly group and 10° latitude range is

NRO (or NR)	-	number of observations analysed.
G	-	number of four-hourly groups of local time 02-06 hours, 06-10 hours, etc., in which at least one observation occurs.
MD	-	mean deviation (m/s) between observations and model; observations were first corrected for the QBO (for sites at latitudes less than 35°) and their differences from the model were then averaged for each of the G four-hourly time groups. The value shown under MD is the average of these G averages. If most of the G groups contain data, that is if data are diurnally well distributed, tidal components are averaged out.
SD	-	standard deviation (m/s) of the distribution of differences from the model.

Table 13 shows the comparison below 60 km for sites between -5°S and 25°N with Table 7 (or Table 8 which is identical with Table 7 at 0°, 10° and 20° latitude). Table 14 shows the comparison for S. Hemisphere data with the S. Hemisphere model (Table 9). Tables 15 and 16 show the comparisons for October to April data from N. American sites and European/W. Asian sites northwards of 25°N with their respective models (Tables 7 and 8). The results for May to September in Tables 15 and 16 are obtained by comparing all data northwards of 25°N with Table 7 (or Table 8 which is identical with Table 7 for these months).

Table 17 shows the comparison of data above 60 km with the model of Table 10. At these heights, S. Hemisphere data are treated as N. Hemisphere data with a six-month change of date. Prevailing wind components, determined by harmonic analysis of radar-meteor observations, are combined with rocket data in this comparison. The large mean deviations at the greater heights are not unexpected in view of the increasing amplitude of tidal and short-period components with height. The monthly intervals in which most data have been collected at $30 (\pm 5)^{\circ}$ sites above 95 km are May 15-June 14 (centred on 1 June) and November 15-December 14 (centred on 1 December). The available profiles for these dates are plotted in Figure 42 together with the model values (Table 10). Deviations from the mean are often 50 to 100 m/s and seen to be greater in winter than summer.

4.2 Temperature Models

4.2.1 SEASONAL MODELS

Figure 43 shows meridional cross-sections of temperature for the first day of each month and latitudes 70^{o}N to 70^{o}S. Data from the S. Hemisphere and N. Hemisphere have been combined with a six-month change of date. As relatively few S. Hemisphere observations are available, the models are biassed to N. Hemisphere conditions.

Below 60 km, the models are based on data at longitudes 70-160 ^{o}W, where most measurements have been made in any case. In the winter months at high latitudes, longitudinal variations are comparable in magnitude with latitudinal variations on account of the Aleutian high pressure area and it is difficult to present realistic models. Data from Fort Churchill (59^{o}N) and Fort Greely (64^{o}N) essentially determine the high-latitude (60 and 70 ^{o}N) regions, which at 25 to 35 km have been made consistent with radiosonde data for 115^{o}W [186].

Above 60 km, data from all longitudes have been combined in construction of the models. Again, most data were from the W. Hemisphere and continuity with the model below 60 km was good.

The tabulated values on which Figure 43 is based appear in the following tables:

Tables 18 a and b - Temperature (^{o}K) 25 to 110 km: below 60 km, values are based on data at longitudes 70-160^{o}W.

An account of the method of preparation of Tables 18 a and b is given in Appendix A.

4.2.2 DIURNAL VARIATIONS

Lack of data has prevented dependence on local time from being taken into account in developing the temperature models. At 50 km and below, MRN measurements have provided a relatively large input of data, but most of these have been taken within a few hours of local noon, thus providing a very poor distribution of data with local time. The models at these lower heights can, therefore, be expected to be biassed towards noon conditions.

Above 60 km, observations have a more even distribution in local time and the model here may be closer to the diurnal mean, although observations are too few for a detailed analysis. For a review of theoretical and observational results of diurnal temperature variations see Section 2.8 and Figure 23. As well as variations of a tidal origin, other temporal variations, due possibly to gravity waves or weather systems, may be present.

4.2.3 COMPARISONS OF TEMPERATURE DATA WITH SEASONAL MODELS

Differences between observed values below 60 km and model values, when interpolated to the same data and launch-site latitude, have been averaged in monthly groups (from mid-month to mid-month) and are shown in Table 19 for a selection of launch sites. Standard deviations and the number of observations are also given. Launch sites lying between 70 and 1ӷ0 °W are marked with an asterisk and were used to develop the temperature models against which they are compared. Mean differences amount to no more than a few °K for all sites, whether they were used for constructing the models or not, except for a few cases which are now discussed.

The high winter values at Fort Greely (64°N, 146°W) and Point Barrow (71°N, 157°W) are attributed to the longitudinal variation referred to in Section 4.2.1 and the westward location of these sites relative to 115°W. At West Geirinish (57°N, 7°W) values are lower than the model except between mid-December and mid-January when they are distinctly higher due to the occurrence of sudden warmings. The lower temperatures could be partly due to the longitudinal variation and partly due to a diurnal effect as these measurements were taken at night, whereas MRN measurements are mostly taken during the day.

Since most of the MRN data listed in Table 3 were obtained before July 1966, it was thought desirable that the models should also be consistent with the monthly mean MRN temperatures from January 1965 to December 1968 for five launch sites lying within 70 to 160°W longitude. The differences between these means and the models interpolated to the same launch-site latitude and the middle of the month have been averaged, and the values obtained are shown in Table 20. The means are seen to be consistent with the models to within a few °K, including those at Ascension Is. which lies at 14°W longitude. The higher differences at Fort Greely in winter are attributed to the longitudinal asymmetry mentioned above.

Table 21 shows comparisons between observed temperatures above 60 km and the model interpolated to the same latitude and date. The mean differences and the standard deviations indicate the magnitude of departure from the model to be expected. Launch sites have been put into three groups according to latitude in view of the small number of observations available at any particular site. Above 90 km, and at times below 90 km, it is apparent that the data are widely distributed in both latitude and season. Such regions of uncertainty are indicated in Tables 18 a and b by asterisks.

4.2.4 TEMPERATURES AT 80°N

When the above temperature models were first prepared they were extended to 80°N, but data from Thule (77°N) and Heiss Is. (81°N) showed significant departures from these values. On account of possible longitudinal variations at high latitudes, it was decided to exclude 80°N values from the final model (they can readily be obtained by extrapolation if needed) and to give a separate 80°N model based on these two stations (Table 22). From 25 to 50 km most of the data were from Thule, and from 50 to 80 km all data were from Heiss Is. In general, stratosphere and mesosphere temperatures at these sites are lower than the extrapolated model in winter and higher in summer (by up to about 20°K).

4.3 Pressure and Density Models

4.3.1 PRESSURE MODEL FOR 30 km

The number of high-level balloon flights has increased considerably in recent years, and data from this source has been used to derive a new model for pressure at 30 km. The sites selected are listed in Table 23. Ideally these should lie along longitude 115°W to be central with the range of rocket-data longitudes (70-160 °W). From monthly mean 10 mb pressure surface levels [187, 188], the mean pressure at 30 km was calculated for the first day of each month. Data were from the years 1958 to 1968 (mostly after 1963) and were taken at 1200 GMT.

Figure 44 shows a plot of the pressures for 1 January and 1 July averaged over all years for which data are available, the data points in brackets being obtained from only two years of data. It is seen that at high latitudes in winter (1) there is a ridge of high pressure (a cross-section of the Aleutian high), (2) pressure decreases very rapidly polewards of this ridge, and (3) much greater variations of pressure occur than at lower latitudes or in the summer hemisphere.

4.3.2 SEASONAL MODELS

Pressure and density models have been calculated from the temperature models and the 30 km pressure model as described in Appendix A:

Tables 24 a and b -	Pressures (N/m^2) 25-110 km: below 60 km, values are based on data at longitudes 70-160°W.
Table 25	- Log (pressure) for the values in Table 24b: the annual mean value and the monthly differences from this value.
Table 26 a and b -	Densities (Kg/m^3) 25-110 km: below 60 km, values are based on data at longitudes 70-160°W.
Table 27	- Log (density) for the values in Table 26b: the annual mean value and the monthly differences from this value.

Below 60 km, the models are representative of the W. Hemisphere being based on temperatures and 30-km pressures for 70-160°W. Above 60 km, some longitudinal dependence will still be present due to the integration involved in obtaining pressure and density from temperature, and to the fact that most temperature data are still from the W. Hemisphere. More data are needed to evaluate longitudinal variations, but apart from the high-latitude winter region, they are expected to be small. In view of the high-latitude longitudinal variation in winter over N. America the pressure and density models, like the temperature models, apply to 115°W longitude at high latitudes (60 and 70°N).

4.3.3 DIURNAL VARIATIONS

Diurnal variations in pressure and density are expected to be present corresponding to those in temperature (Section 4.2.2). As in the case of temperature, data were insufficient for a general analysis of the dependence on local time.

A diurnal bias may be present in the pressure and density models arising partly from that in the temperature models which are biassed towards local noon (at 50 km and below), and partly from that in the base-line pressure model (at 30 km) which was developed from 1200 GMT balloon data (corresponding to local times between 0400 and 0630 hours according to the longitude). However, diurnal amplitudes are smaller at 30 km than at 40 and 50 km, and the major bias in the pressure and density models is expected to arise from that in the temperature models at these heights and so be towards local noon conditions. In this respect, the new models follow those of CIRA 1965, in the publication of which [1] a comparison showed MRN pressures at 30° latitude to exceed grenade experiment pressures (which are not generally biassed towards local noon) by 6 percent and densities by 3 percent at 40 to 50 km. At low latitudes, where the seasonal variation is relatively small, a formal analysis for diurnal harmonics has given significant results shown in Figures 45 and 46.

4.3.4 COMPARISONS OF PRESSURE AND DENSITY DATA WITH THE MODELS

4.3.4.1 Introduction

Unlike the comparisons of wind and temperature data with their respective models (Sections 4.1.5 and 4.2.3), the comparisons of pressure and density data with the pressure and density models check different methods of normalization or calibration. Densities obtained by falling spheres are dependent on the absolute determination of drag coefficients, whereas grenade densities and pressures and the models themselves are obtained by integration with respect to height from a base level where these conditions are known. Results obtained directly by pressure sensors involve certain calibration procedures.

4.3.4.2 Low-latitude Sites

At low latitudes seasonal variations are small, and examination of available data as a function of local time has shown that a significant diurnal variation is present at the greater heights. A diurnal variation in density at 90 km was previously reported [189] using data from latitudes of less than 10°. Data have now been formally analysed for 24- and 12-hour components using the method of least squares to determine A_o, A_1, A_2, t_1 and t_2 in the expression

$$p \text{ (or } \rho) = A_o + A_1 \cos \pi(t - t_1)/12 + A_2 \cos \pi(t - t_2)/6 \qquad (4)$$

The results obtained are given in Figures 45 and 46.

The increasing importance of diurnal variations with height is illustrated in Figure 47 where pressure and density observations are plotted with the least-squares curves of the form Eq. (4), except at 40 km where the harmonics were not significantly determined and the mean value is plotted. The arrows on these figures are from the models, being the mean of the 12 monthly values, and they are seen to lie within the range of the diurnal variation. At 90 km, the model means and the fitted curves cross close to 1000 hour and 1530 hour local time, lending support to statements above that the diurnal distribution of data is expected to cause the models to be biassed towards local noon conditions. At 65 km, the corresponding times are again close to noon.

In Figure 48 pressure and density data are plotted against date of observation, after correcting the 65- and 90-km values for the diurnal variation. The correction was carried out by plotting the data points in these figures at displacements from the model mean value equal to their displacements from the curves in Figure 47. It is, therefore, no coincidence that the data points lie fairly symmetrically about the seasonal models at 65 and 90 km in Figure 48, but it is significant that the data appear to follow the small semi-annual variation of the models in certain cases. On the basis of the semi-annual variation shown by the models, all data points were, therefore, corrected to 1 January and the analysis for the 24- and 12-hour components using Eq. (4) was repeated to obtain the results in Figures 45 and 46.

4.3.4.3 30° Latitude Sites

An earlier examination [189] of 90-km density data from rocket launchings at Carnarvon (25°S), Eglin (30°N), Woomera (31°S) and White Sands (32°N) failed to reveal any systematic variation with local time. This is not to say that such a variation is not present, but only that it is not apparent with the rather uneven distribution of local times of launchings. Data at 40, 65 and 90 km from these and other 30° latitude sites have, therefore, been plotted against date of observation

(with a 6-month change of date for S. Hemisphere sites) and compared with the 30°N models. In plotting the data points, a correction was made for the departure of launch sites from 30°; such corrections were, however, quite small. The comparisons are shown in Figure 49.

4.3.4.4 37.5°N Latitude Sites

Data from Wallops Is. (37.8°N) and Arenosillo, Spain (37.1°N) are compared in Figure 50 with the pressure and density models for 37.5°N latitude.

4.3.4.5 59°N and 71°N Latitudes

Fort Churchill observations are compared with the pressure and density models for 59°N in Figure 51, and Point Barrow observations are compared with the 71°N models in Figure 52. A large seasonal variation is present at these latitudes; at 65 km, for example, summer values exceed winter values by a factor of more than two. At 90 km, however, a semi-annual component appears in the density with a well-defined maximum in April and a small maximum in September (Section 4.3.5).

Figures 51 and 52 show that winter data at Fort Churchill (94°W) are generally lower than the model, whereas those at Point Barrow (157°W) exceed the model. Longitudinal temperature variations are present in the stratosphere over high N. American latitudes in winter (Section 2.3), temperatures being higher to the W. (towards the Aleutian high). In the mesosphere, pressures and densities can also be expected to be higher to the W., while the model, which is based on 115°W stratospheric temperatures, is intermediate to the two sites.

4.3.5 DENSITY MODEL AT 90 km

The seasonal variation of density at 90 km is shown in Figure 53 for a range of latitudes, together with the variations at 80 and 100 km for comparison. At low latitudes, variations with both season and latitude are small at all three levels; but as latitude increases an annual variation develops at 80 km with higher densities in summer than winter, whereas at 100 km an annual variation develops with minimum densities in summer. At 90 km, these two variations are partially self-cancelling, giving rise to a level of reduced density variation with the occurrence at most latitudes of two maxima and two minima in the year. The variation of air density at 90 km has been examined by Cook [200] and the similarity of phase with the well-known semi-annual variation at satellite heights pointed out. The presence of semi-annual effects still remains one of the least understood phenomena of upper atmosphere structure.

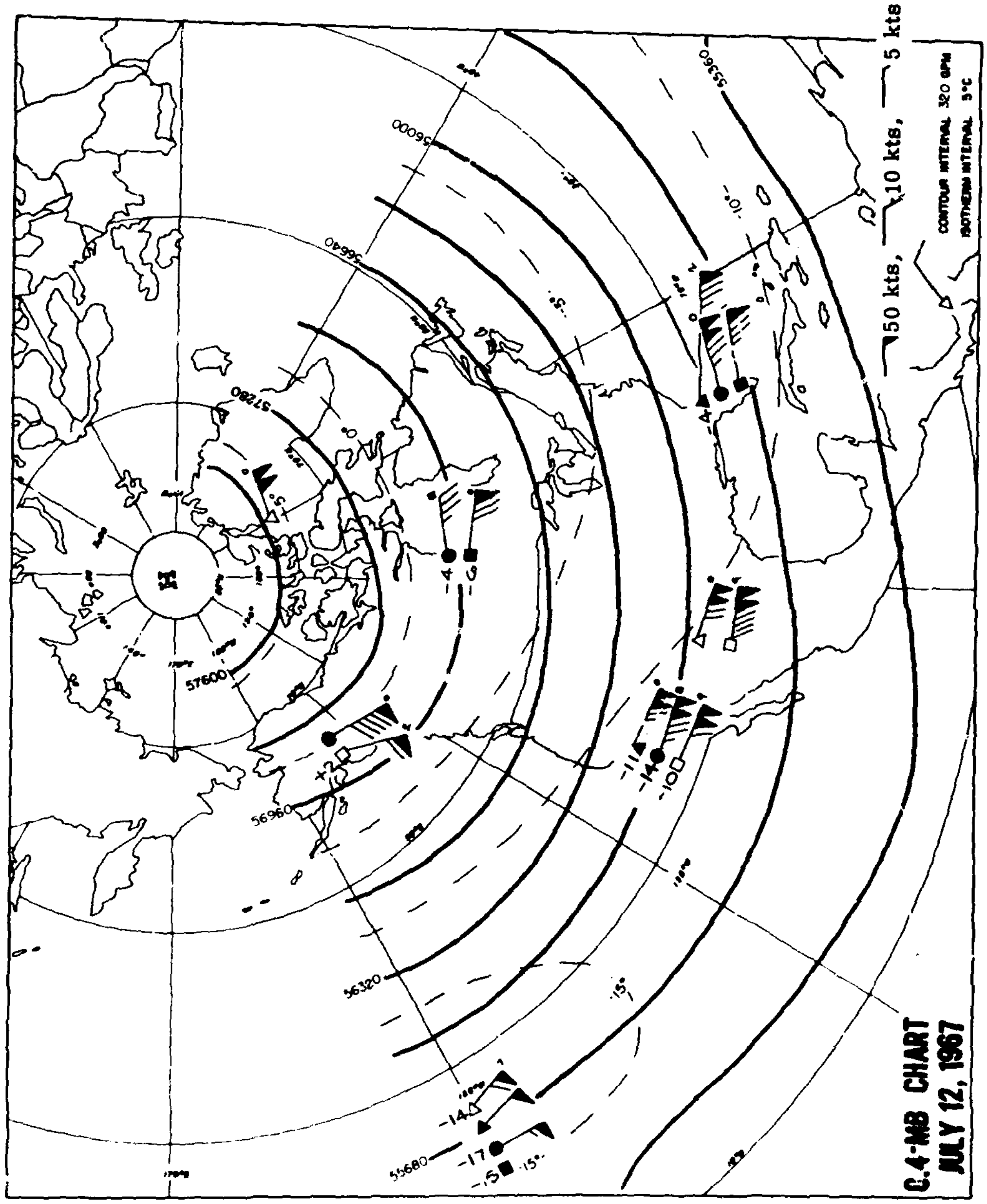


Figure 1. Chart (0.4 mb) for 12 July 1967 [72]

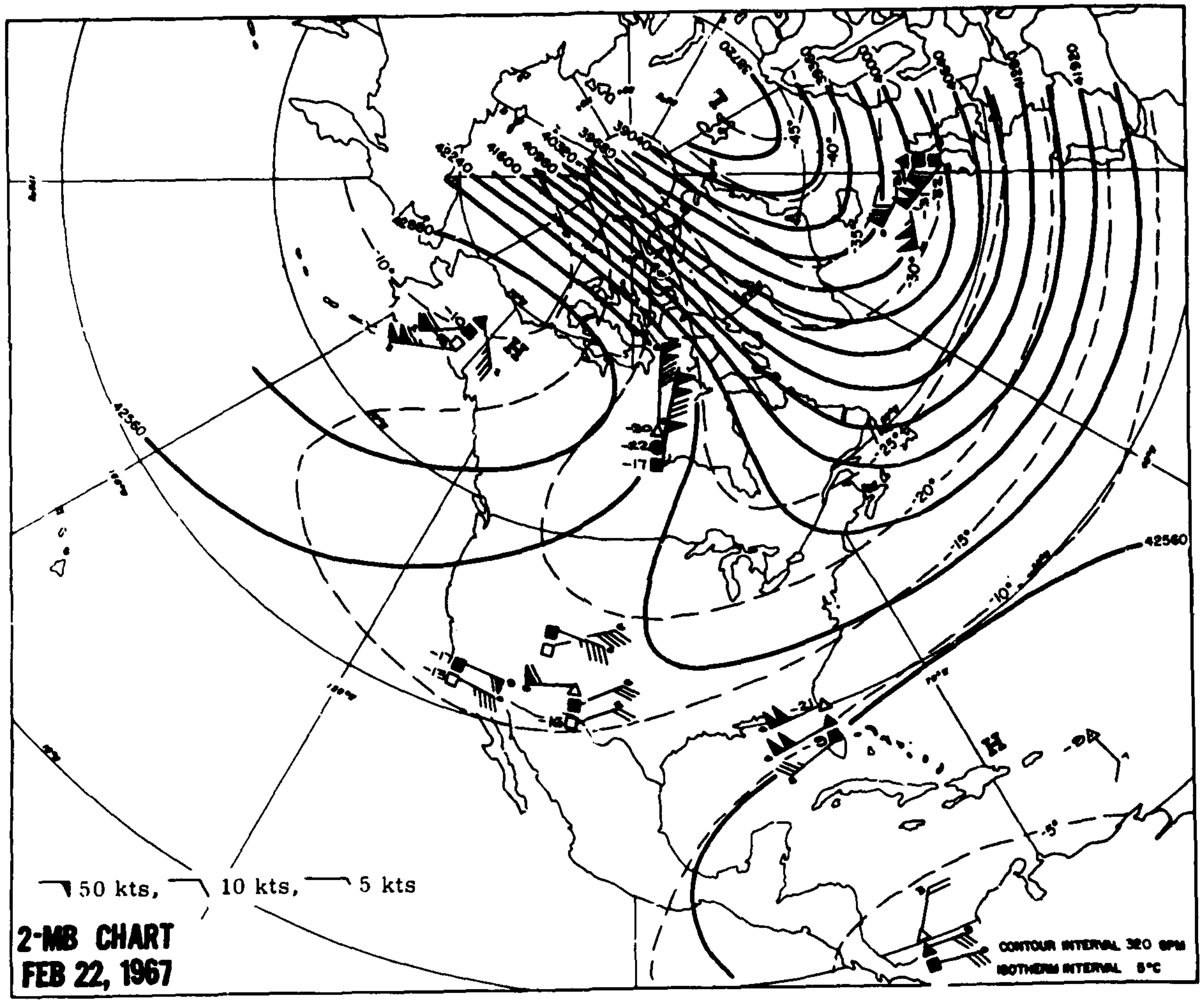
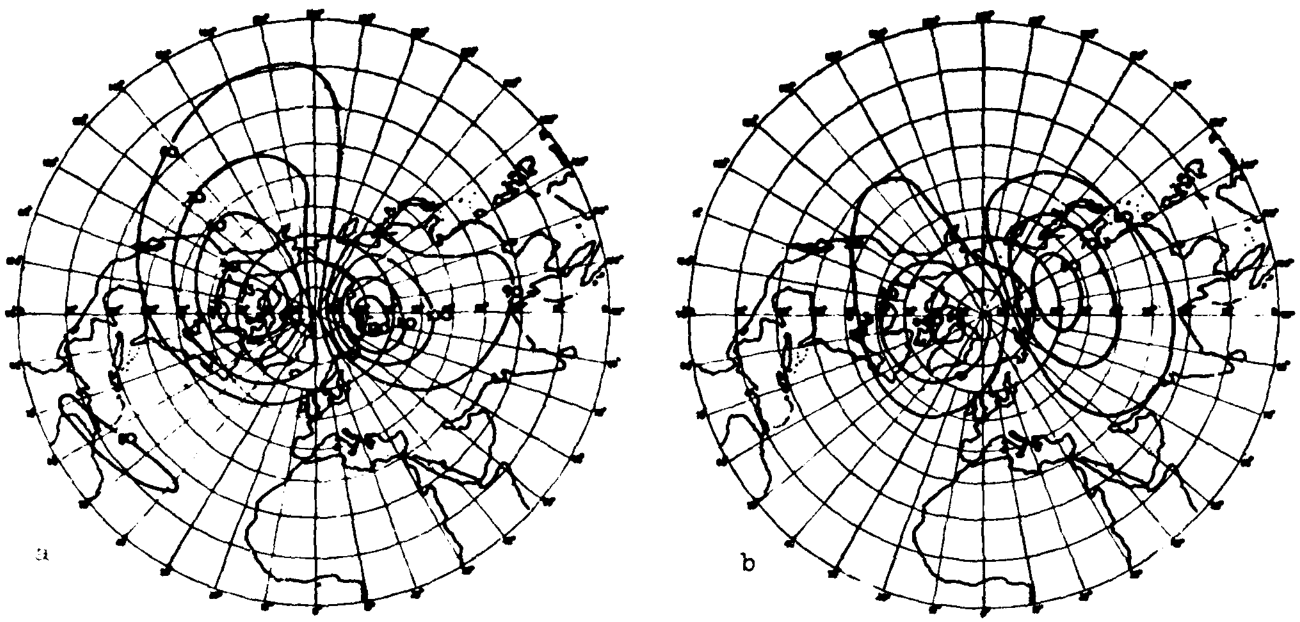


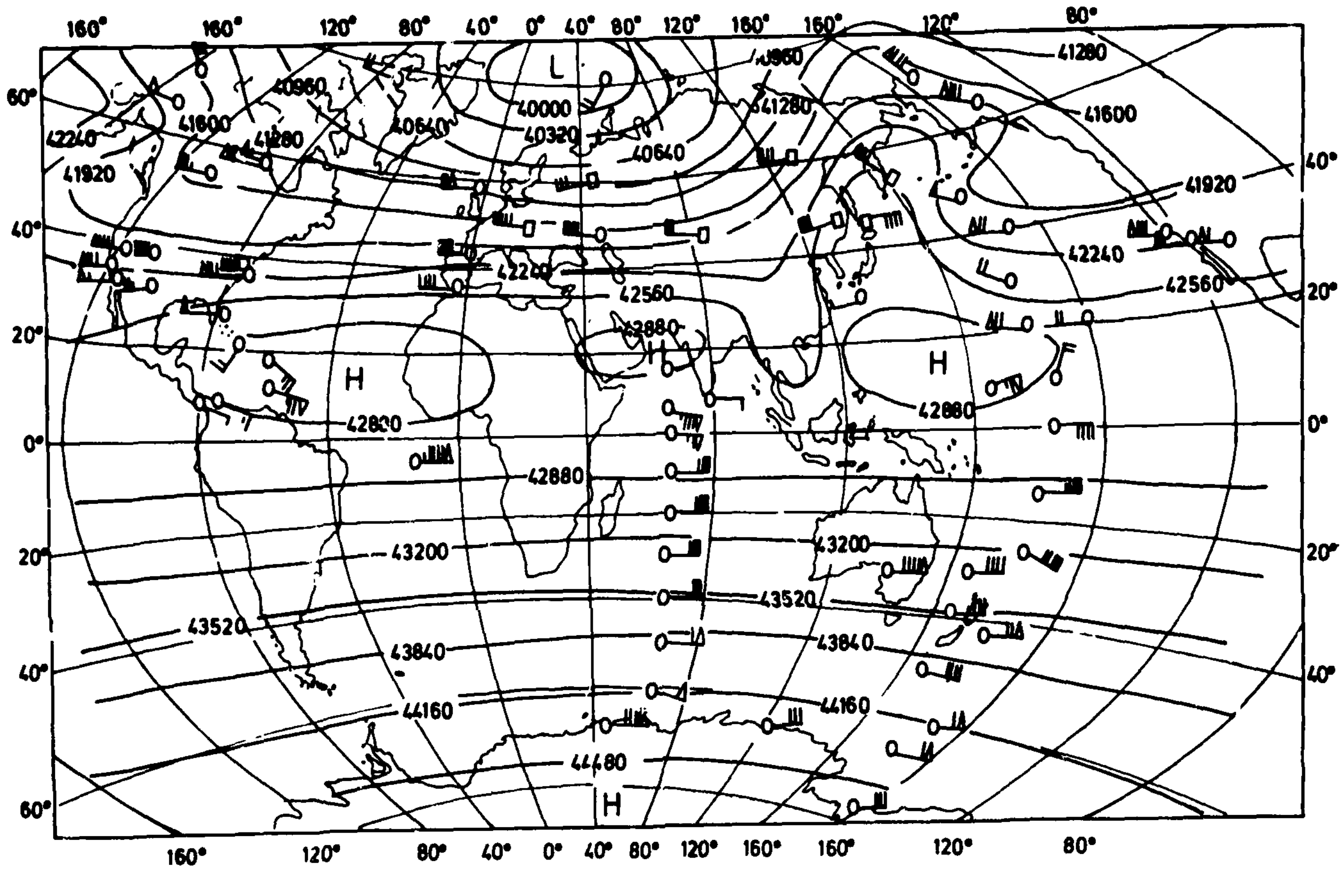
Figure 2. Chart (2 mb) for 22 February 1967 [72]



Maps a and b show Isopleths of Radiance mW m^{-2} sr^{-1} $(cm^{-1})^{-1}$ From Channels A and B. Equivalent temperatures of a black body which would give the same radiance are:

Radiance	Equivalent temperature (^{o}K)
30	201.0
40	213.7
50	224.7
60	235.5
70	243.6
80	251.9
90	259.8
100	267.8
110	274.2
120	281.0

Figure 3. NIMBUS 4 North Polar Stereographic Maps. Each map was derived from data of 12 orbits extending to 80°N. (a) Channel A (approx. 2 mb) 4 January 1971; (b) Channel B (approx. 20 mb) 4 January 1971 [79]



Key:
2-3 m/s; 5 m/s; 25 m/s; 50 m/s

Figure 4. Constant Pressure Chart (2 mb) for January [48]

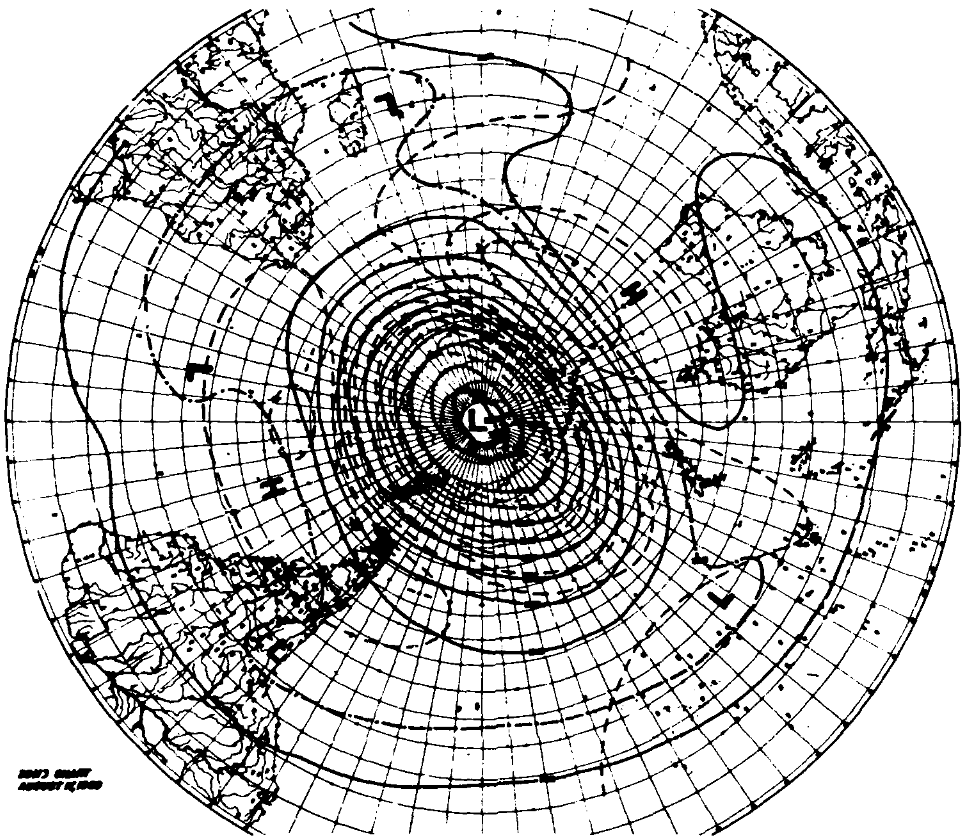
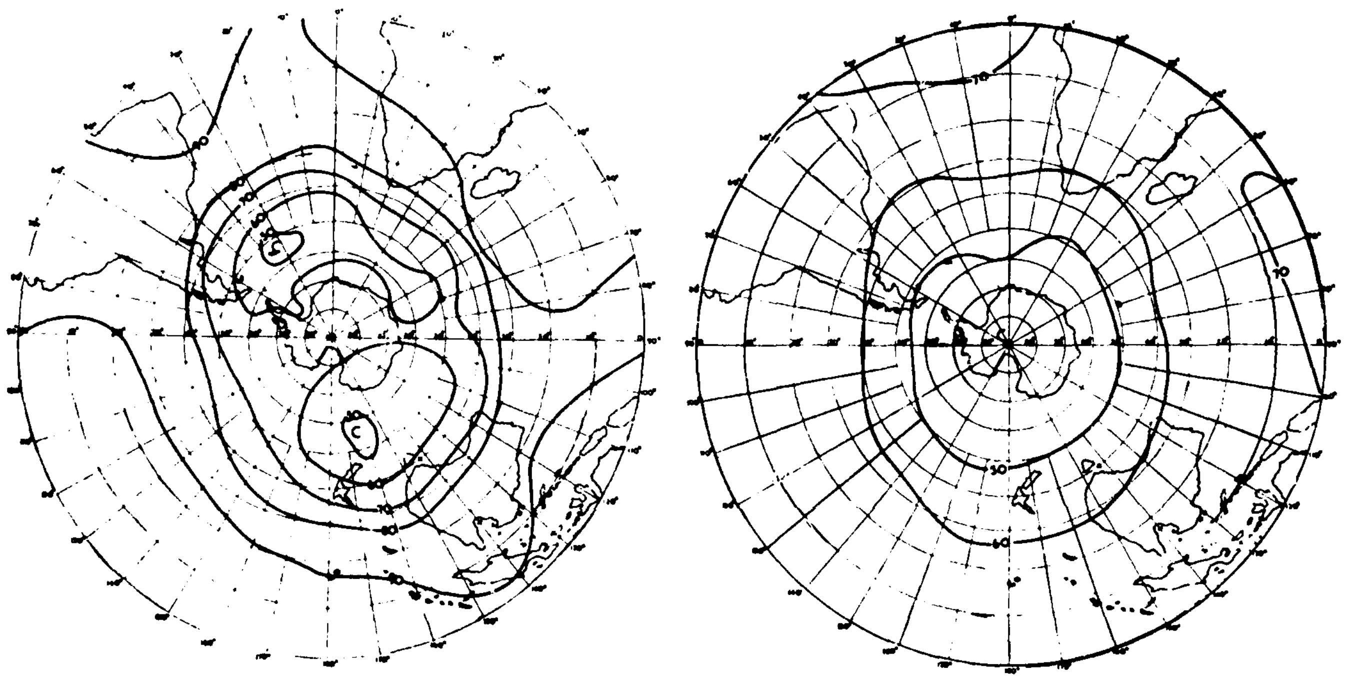


Figure 5. Analysis Chart (30 mb) for 17 August 1969. Units: geopotential meters and degrees Celsius [90]



a b

Figure 6. NIMBUS 4 Maps Showing Isopleths of Radiance mW m^{-2} s^{-1} From Channels A and B. Equivalent temperatures of a black body which would give the same radiance are given in Figure 3. C shows cold areas. Maps are for 22 June 1970. (a) S. Hemisphere channel A; (b) S. Hemisphere channel B [75]

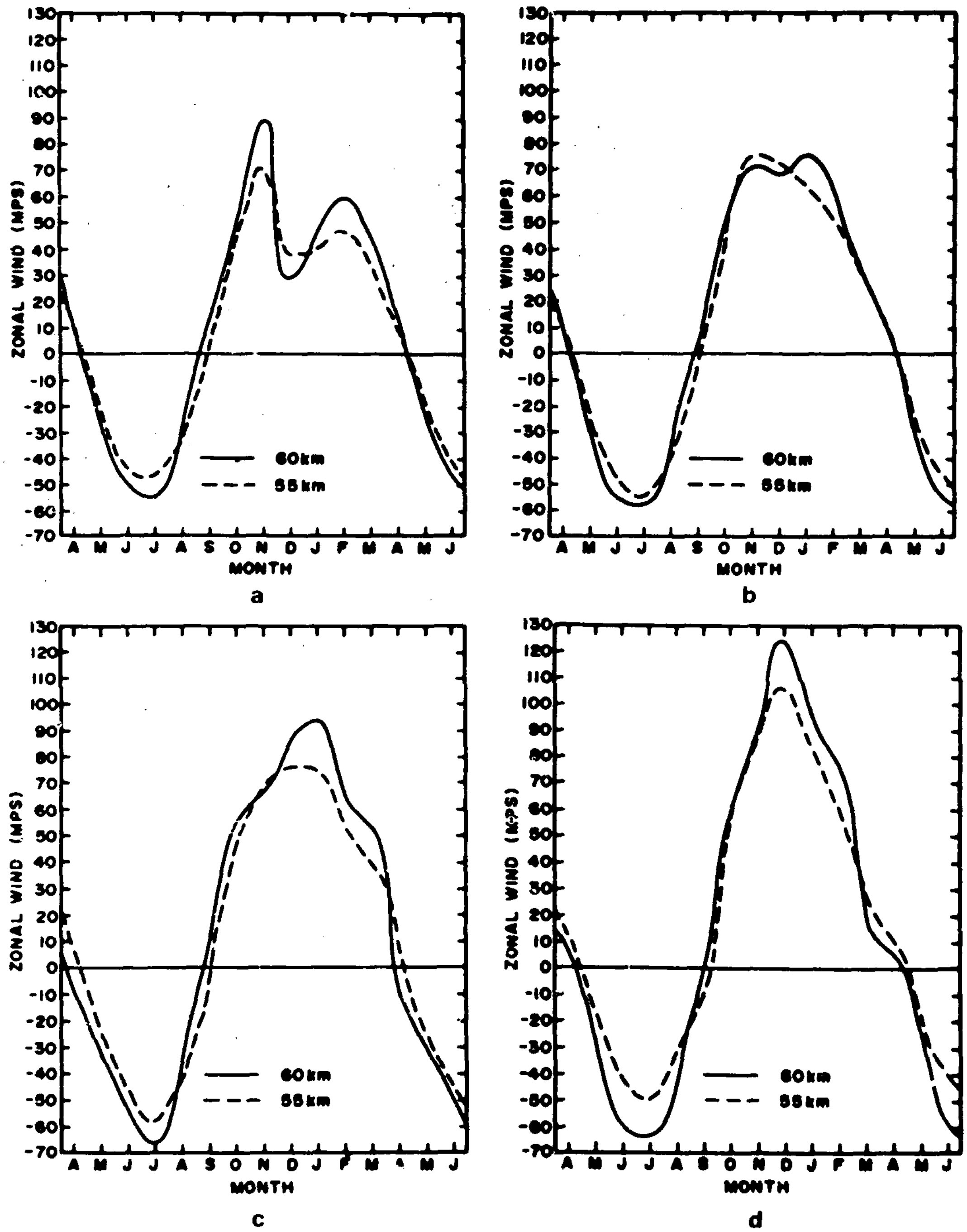


Figure 7. Seasonal Variation of Zonal Wind Component at 55 and 60 km at (a) Cape Kennedy, 28°N; (b) White Sands, 32°N; (c) Point Mugu, 34°N; (d) Wallops Is., 38°N [91]

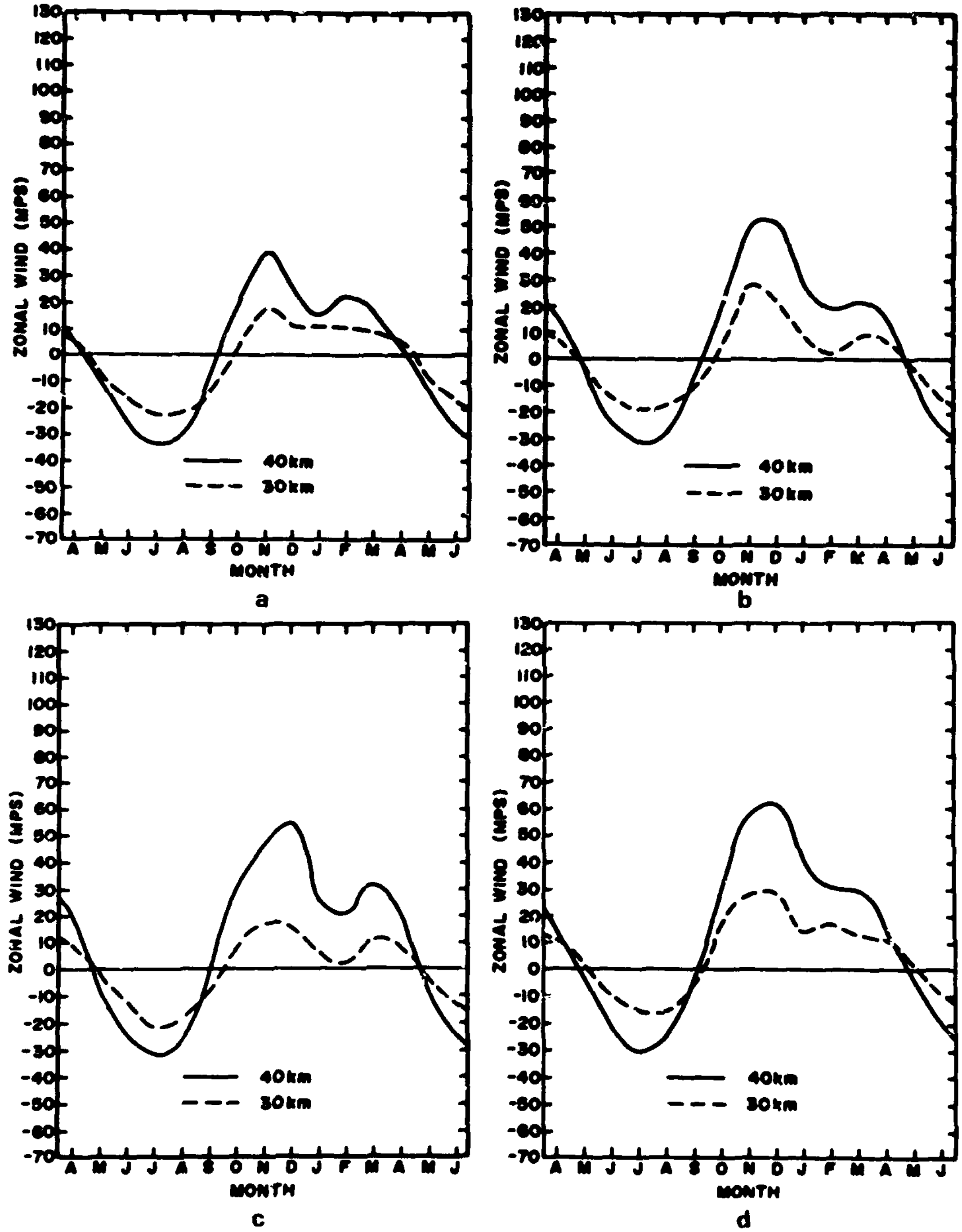


Figure 8. Seasonal Variation of Zonal Wind Component at 30 and 40 km at (a) Cape Kennedy, 28°N; (b) White Sands, 32°N; (c) Point Mugu, 34°N; (d) Wallops Is., 38°N [91]

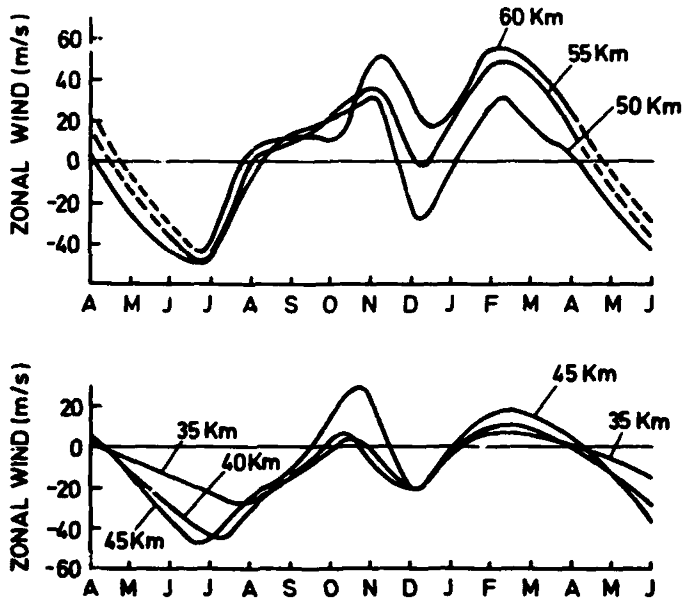


Figure 9. Seasonal Variation of Zonal Wind Component at Sonmiani (25°N) [92]

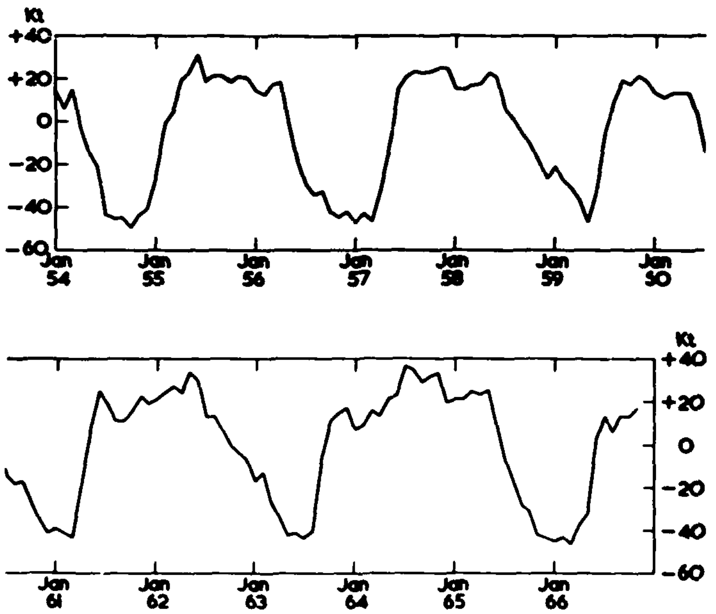


Figure 10. Monthly Mean Zonal Wind Components at 50 mb for Canton Island (2° 46'S, 171° 43'W). Components towards the east are positive [94]

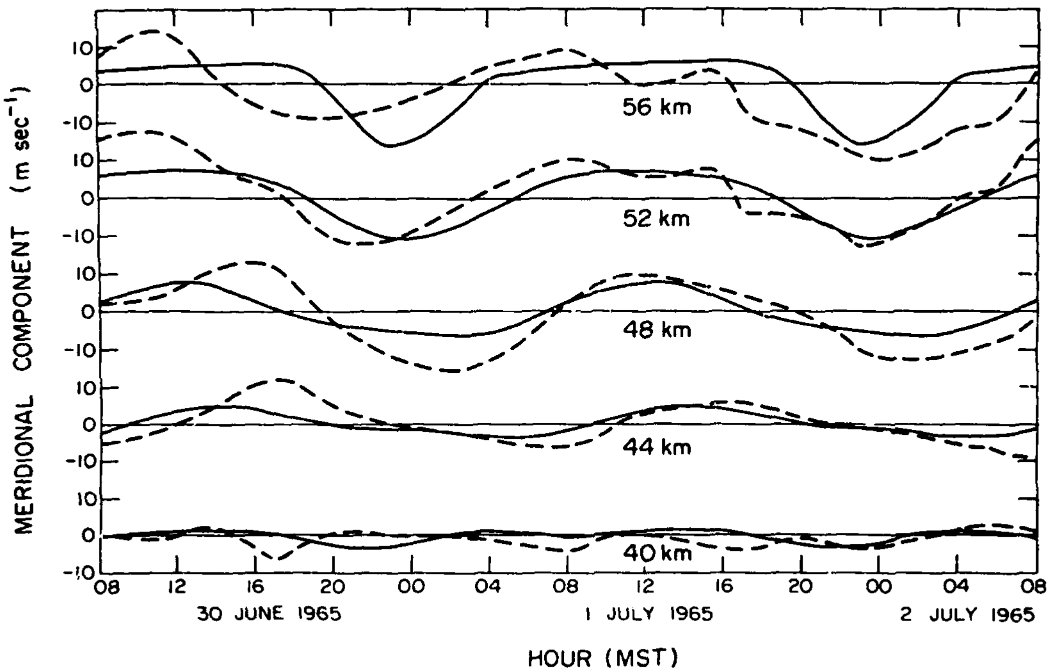


Figure 11. Mean Diurnal Variation of Meridional Wind Component in Summer for White Sands and Cape Kennedy Combined (Solid Line) and Variation for 2-day Period at White Sands [109], [102]

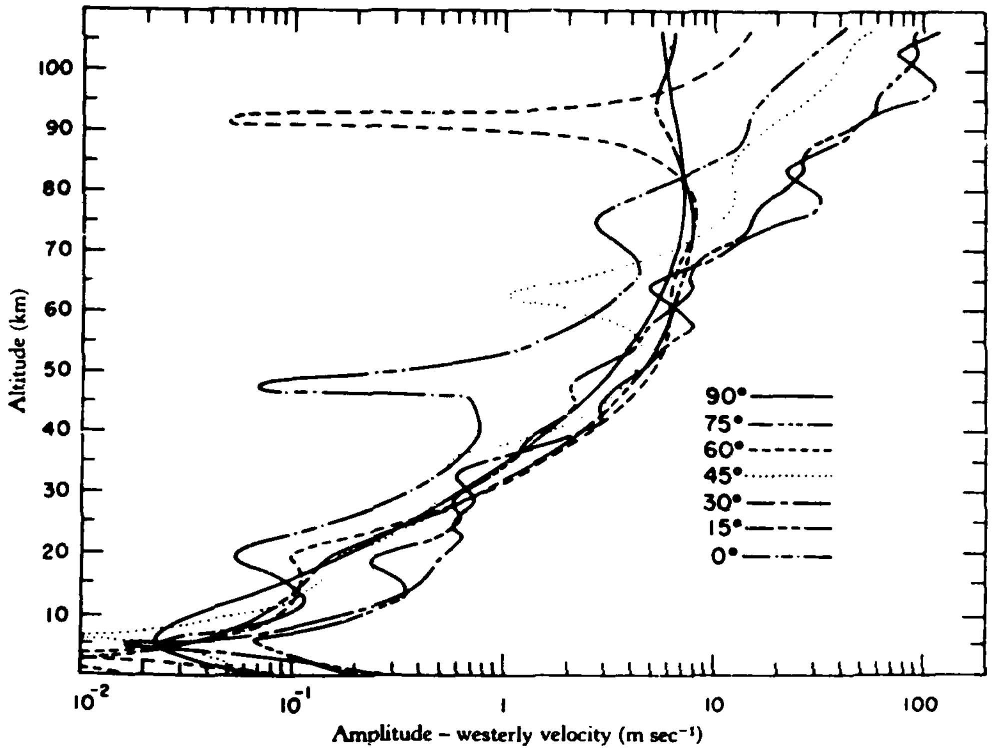


Figure 12. Altitude Distribution of the Amplitude of the Solar Diurnal Component of the W-E Flow at 15° Intervals of Latitude for Equinoctial Conditions [104]

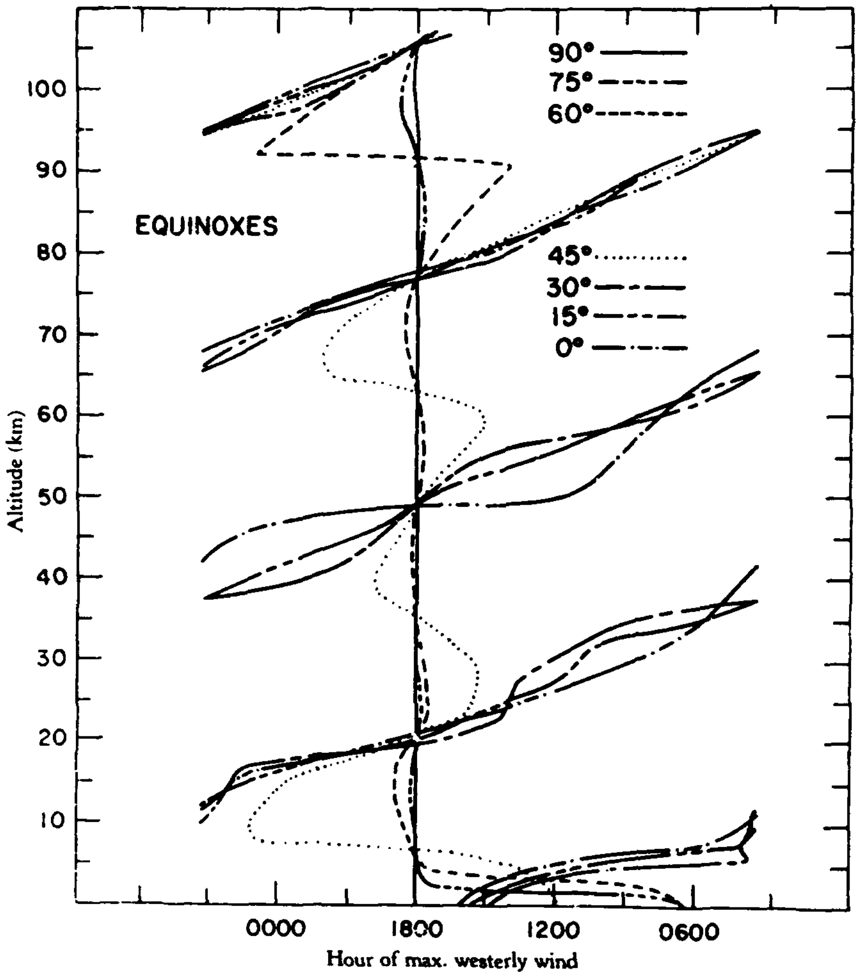


Figure 13. Altitude Distribution of the Phase of the Solar Diurnal Component of the W-E flow at 15° Intervals of Latitude for Equinoctial Conditions [104]

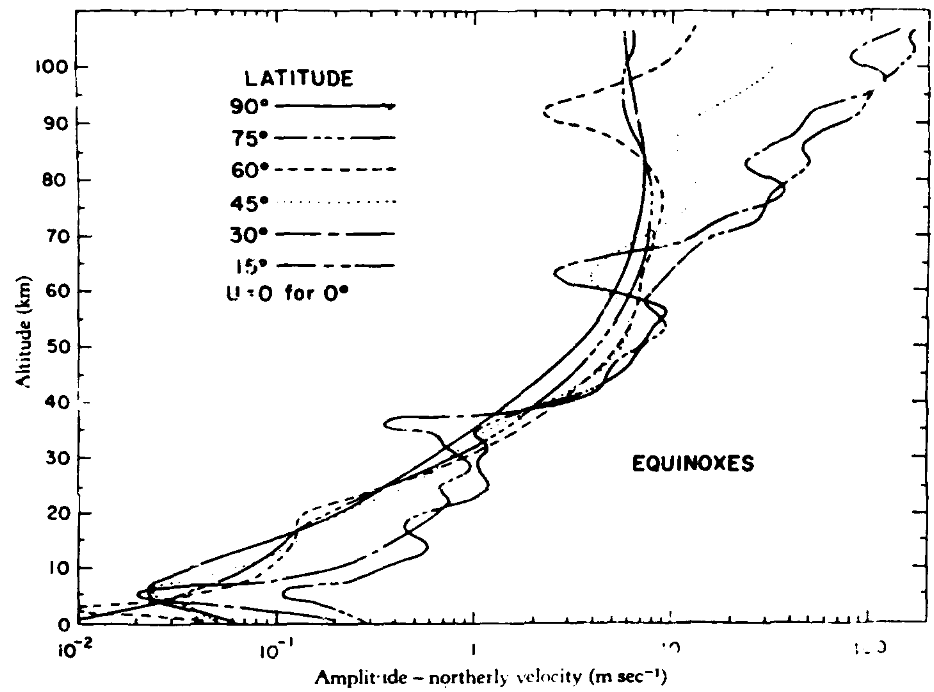


Figure 14. Altitude Distribution of the Amplitude of the Solar Dirunal Component of the N-S Flow at 15° Intervals of Latitude for Equinoctial Conditions [104]

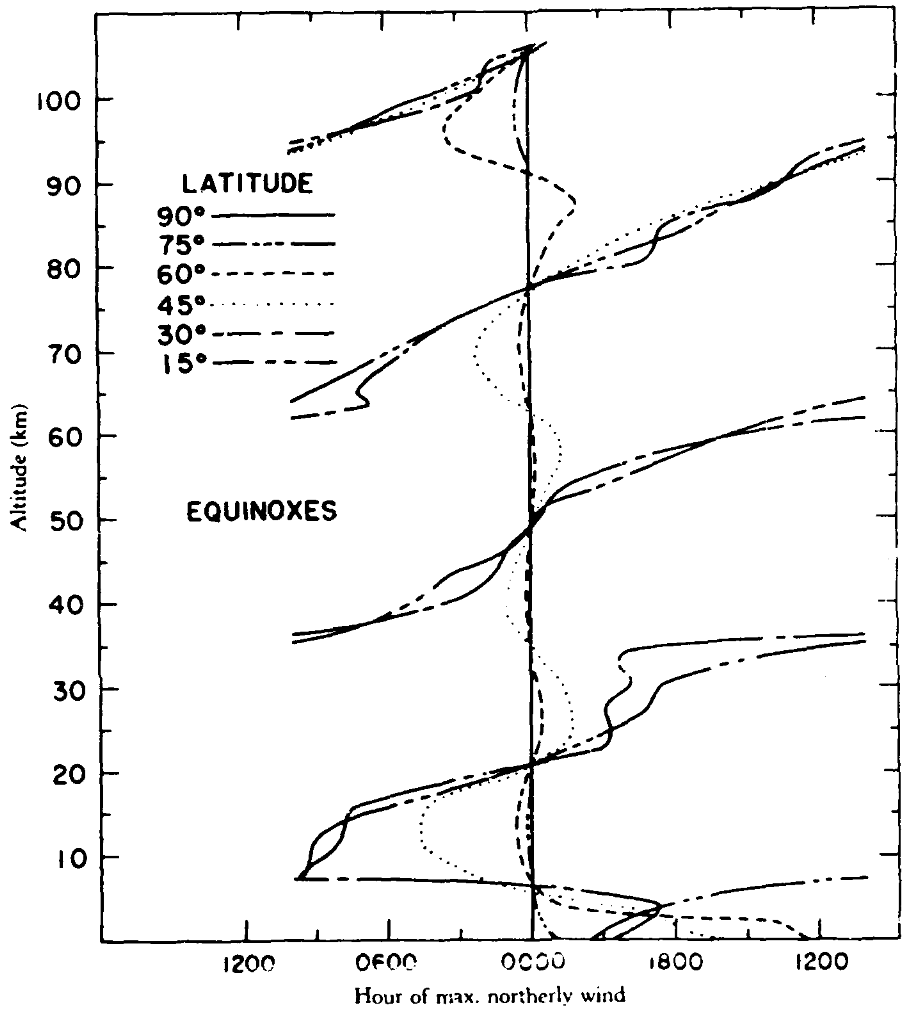


Figure 15. Altitude Distribution of the Phase of the Solar Diurnal Component of the N-S Flow at 15° Intervals of Latitude for Equinoctial Conditions [104]

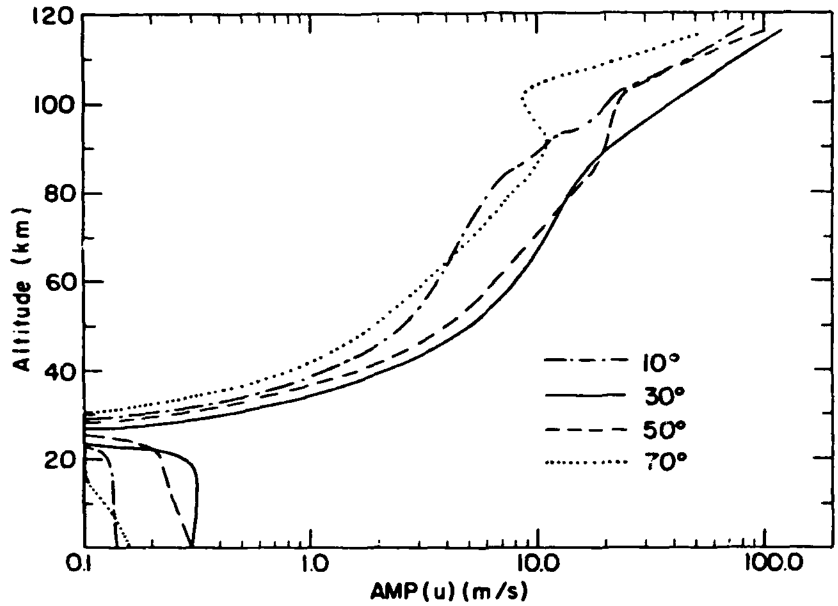


Figure 16. Amplitude of the Solar Semidiurnal Component of the N-S Flow (u) at Various Latitudes. Equatorial $T_o(z)$ assumed [103]

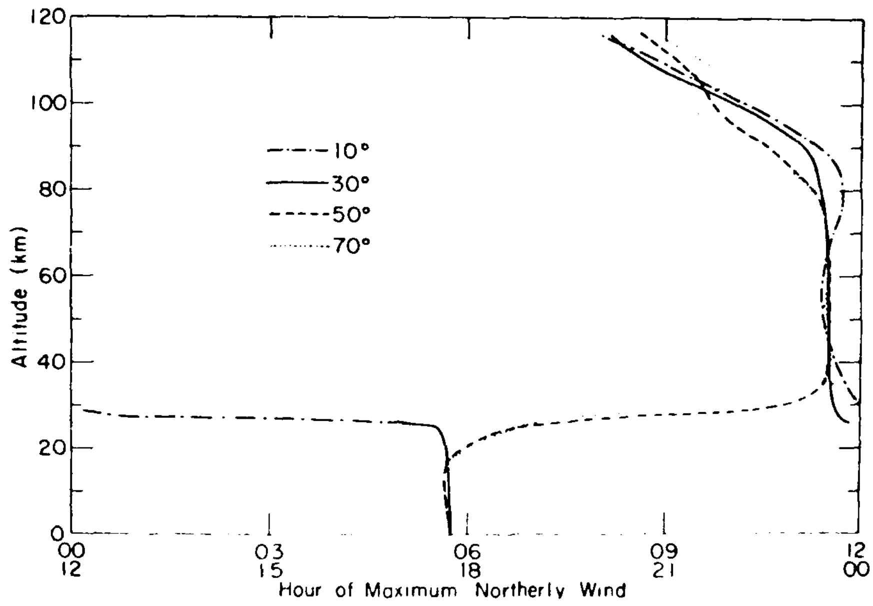


Figure 17. Phase (Hour of Maximum) of the Solar Semidiurnal Component of the N-S Flow at Various Latitudes. Equatorial $T_o(z)$ assumed [103]

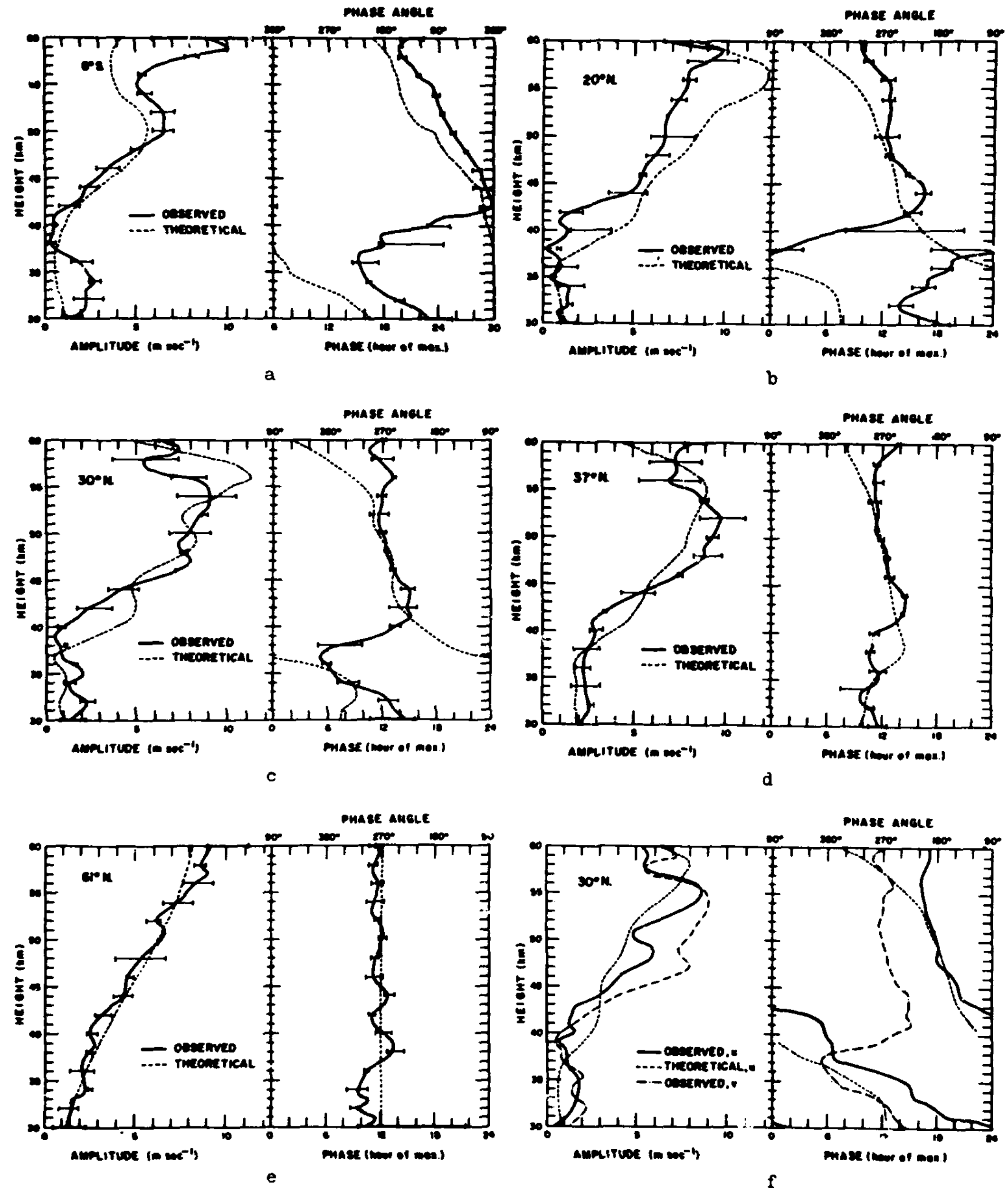


Figure 18. Amplitude and Phase of Diurnal Variation of Meridional Wind Component at Various Latitudes. The phase angle, in accordance with usual convention, gives the number of degrees in advance of origin (chosen as midnight) that the up-crossing of the sine curve occurs. Amplitude and phase of the diurnal variation of zonal wind component at 30°N are shown in f, and data for meridional component are also shown [105]

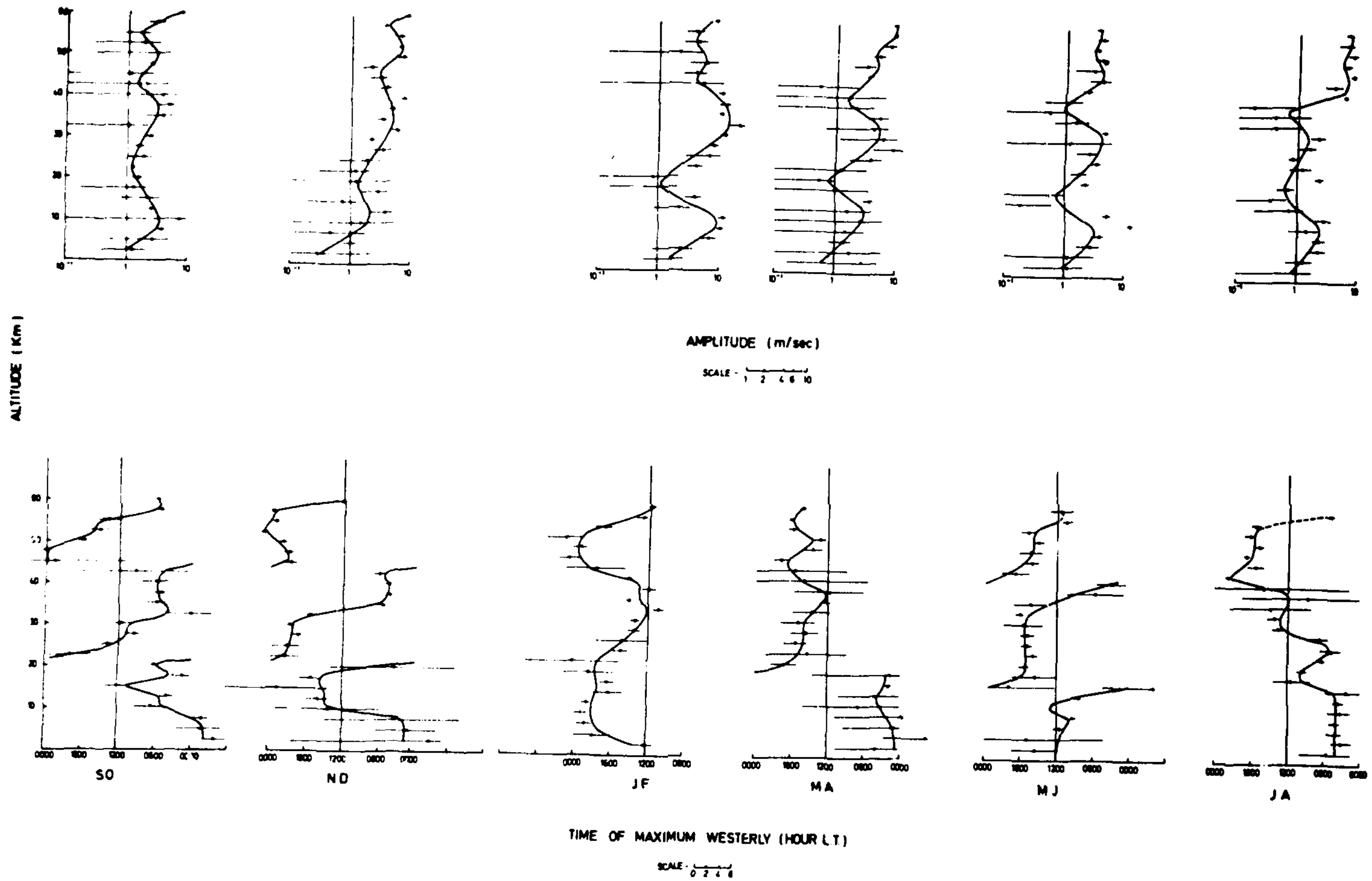


Figure 19. Seasonal Variation in the Amplitude and Phase of the Diurnal W-E Wind Component at 31.5°N [106]

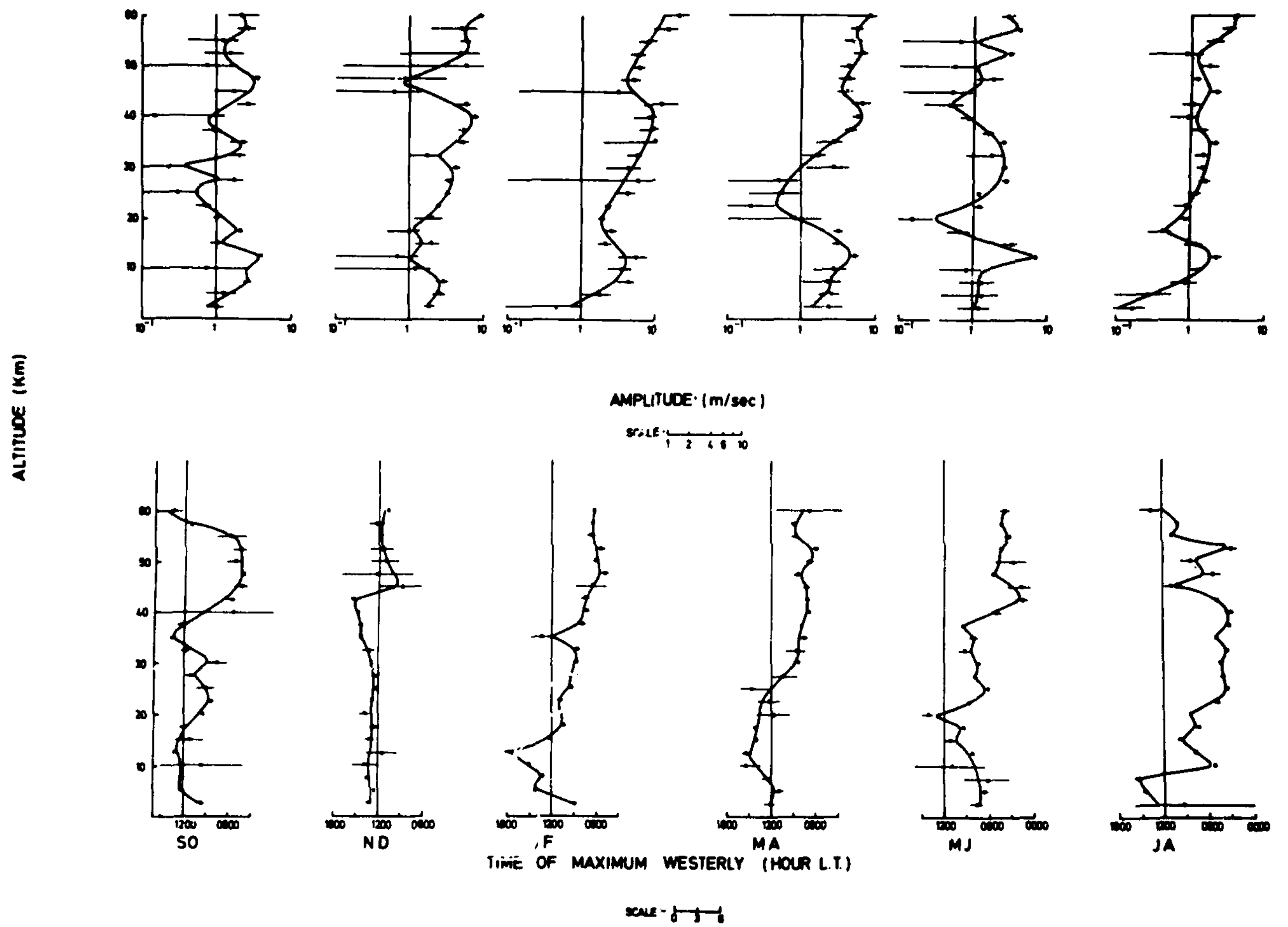


Figure 20. Seasonal Variation in the Amplitude and Phase of the Semidiurnal W-E Wind Component at 31.5°N [106]

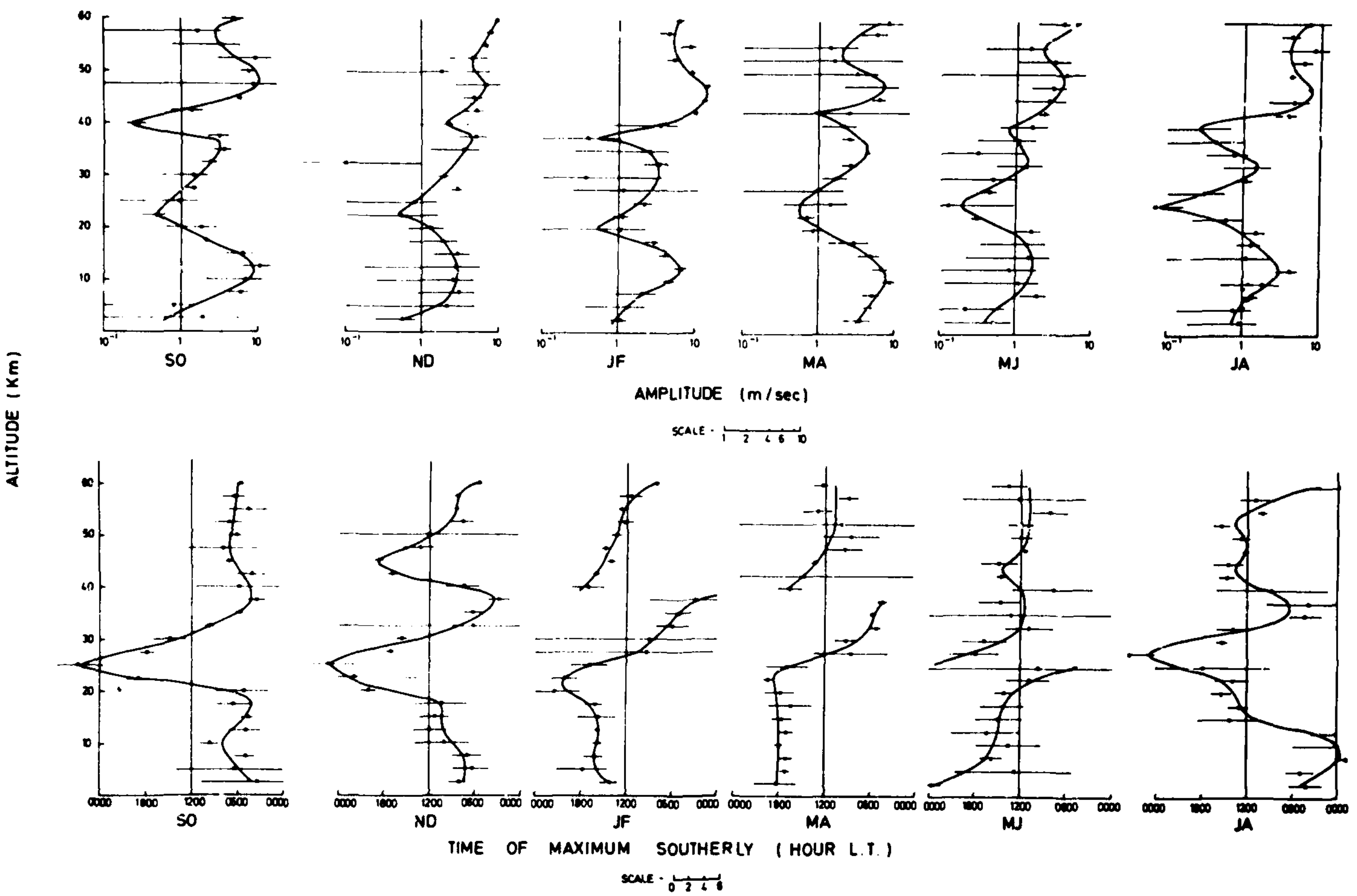


Figure 21. Seasonal Variation in the Amplitude and Phase of the Diurnal S-N Wind Component at 31.5ON [106, 107]

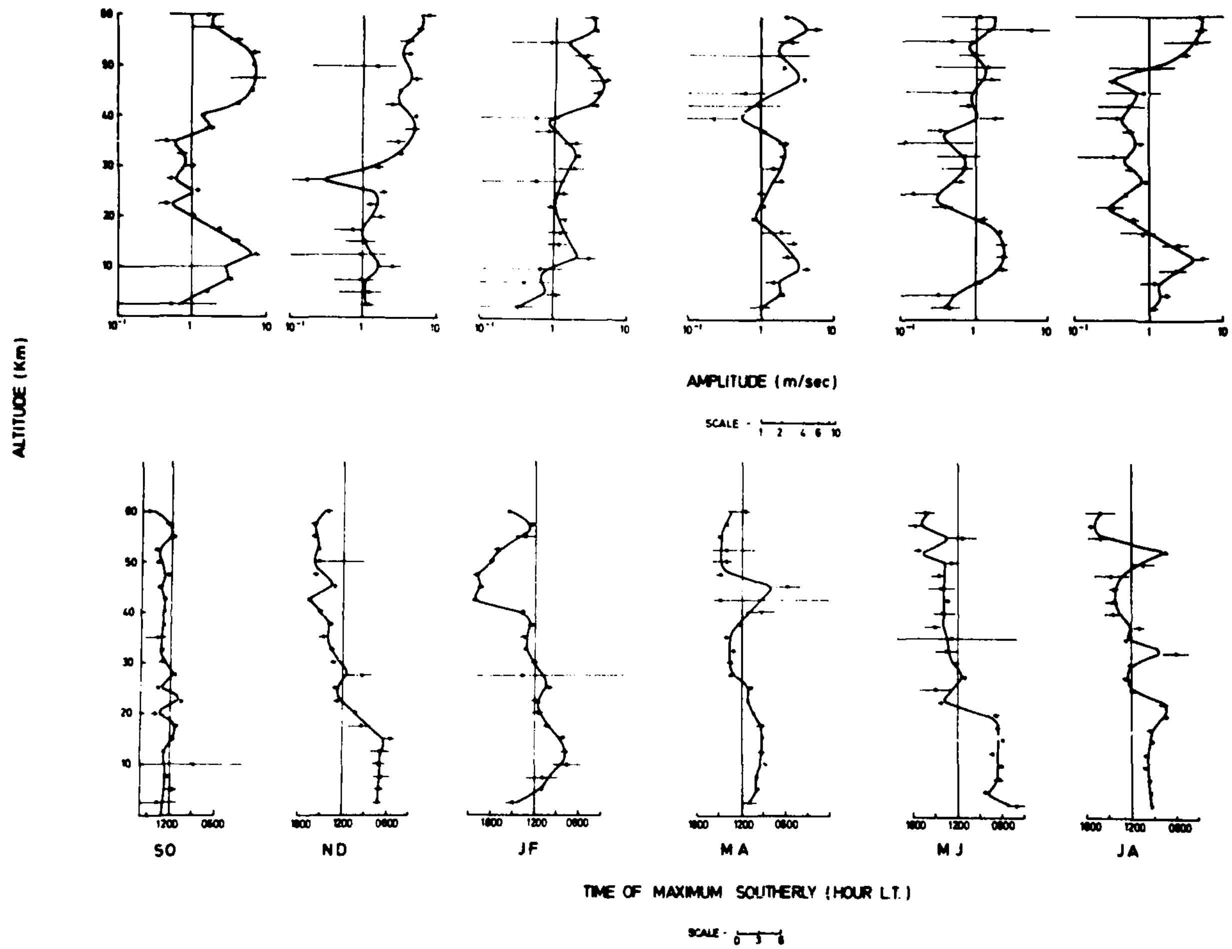
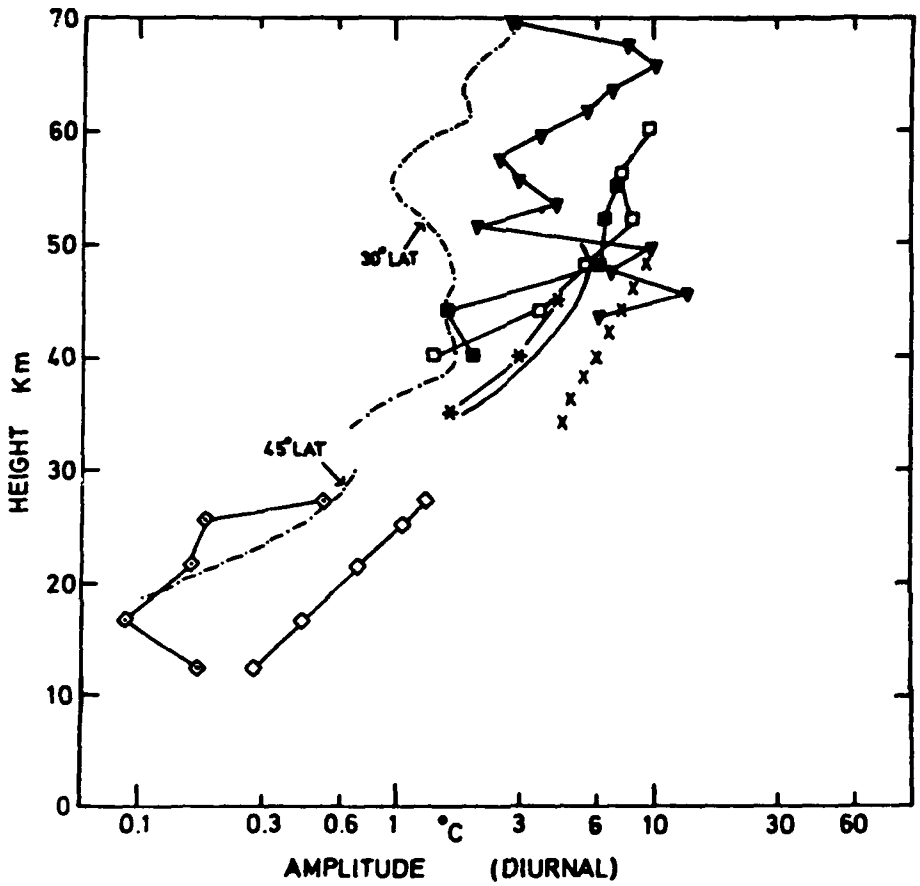


Figure 22. Seasonal Variation in the Amplitude and Phase of the Semidiurnal S-N Wind Component at 31.5°N [106, 107]



Key to symbols:

- □ White Sands (32°N) 30 June-2 July 1965 [109]
- ▼ Carnarvon (25°S) 10-11 May 1965 [110]
- ■ White Sands (32°N) 7-8 February 1964 [111, 112]
- X Wallops Island (38°N) 8-10 September 1965 (temperature analysis) [111]
- ✱ Wallops Island (38°N) 8-10 September 1965 (wind analysis) [111]
- — Theoretical(Johnson 1953) [111]
- -·- Theoretical (Lindzen 1967) [104]
- ◇ 8 Stations Balloon Data (observed) [113]
- ◈ 8 Stations Balloon Data (computed from winds) [113]

Figure 23. Comparison of Diurnal Temperature Amplitudes [108]

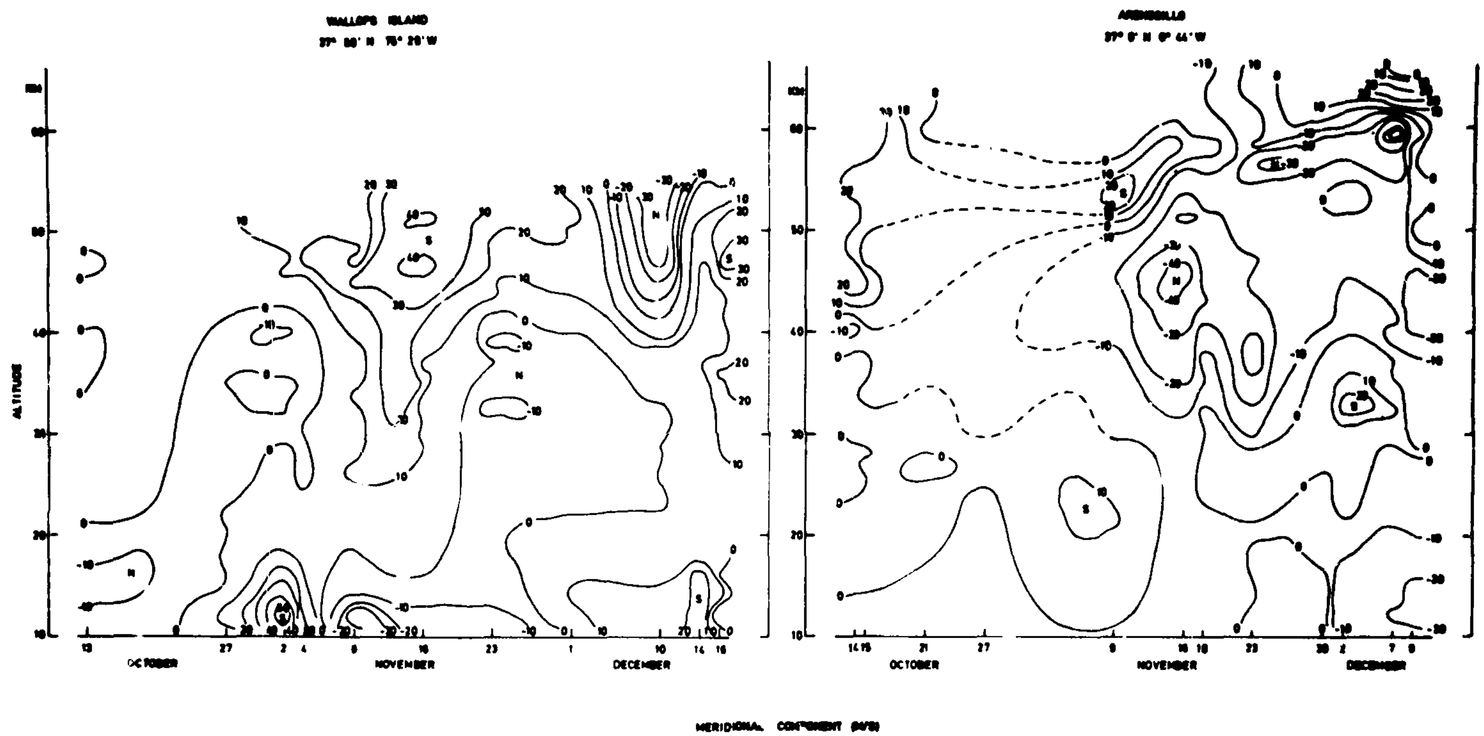


Figure 24. Longitudinal Differences in Meridional Winds at Wallops Island ($38^{o}N$, $75^{o}W$) and Arenosillo ($37^{o}N$, $7^{o}W$) 12 October-17 December 1966 [115]

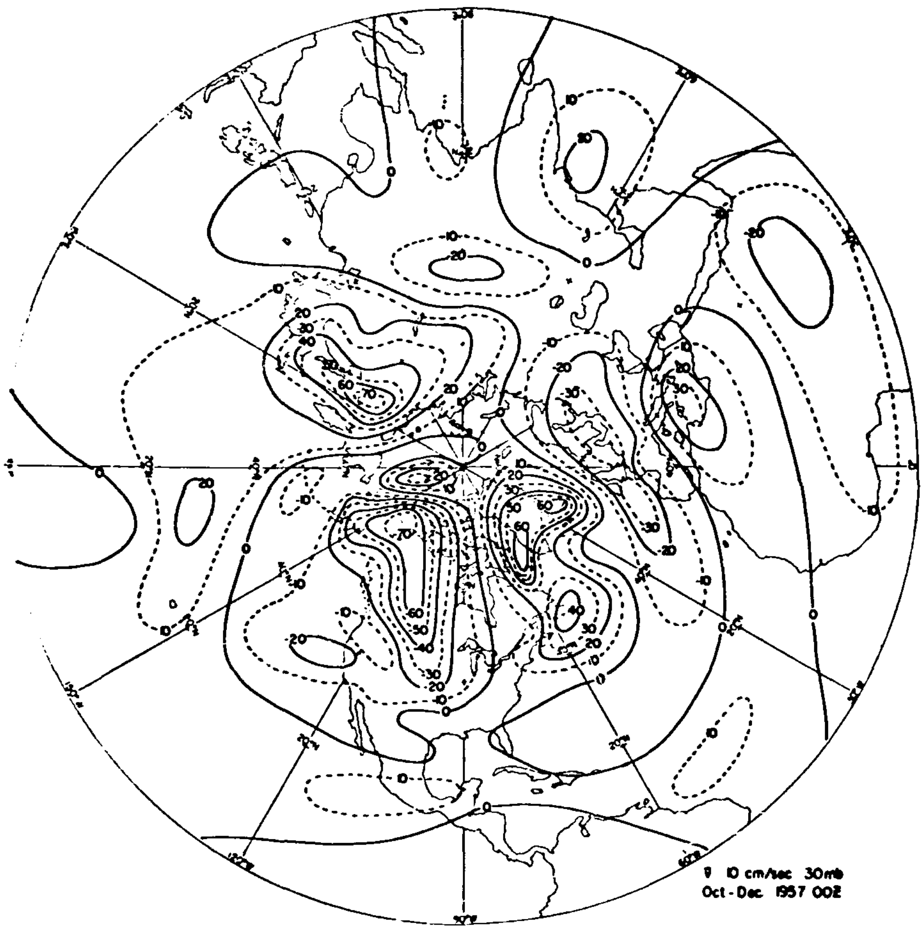


Figure 25. Mean Meridional Wind. Isolines are drawn at 1 m/s intervals. Positive values indicate motion from south to north, and negative values from north to south [117]

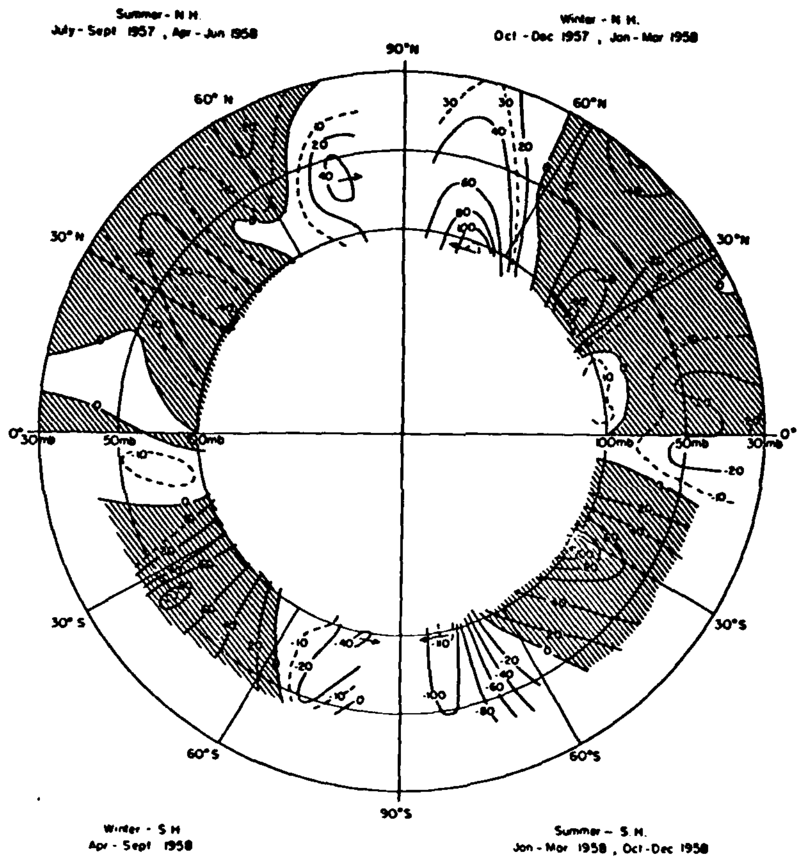


Figure 26. Cross Section of the Zonally Averaged Mean Meridional Flow Through the Stratosphere (100-30 mb) of Both Hemispheres for Winter and Summer 1957-8. The regions of equatorward motion are shaded. Units are cm/s [117]

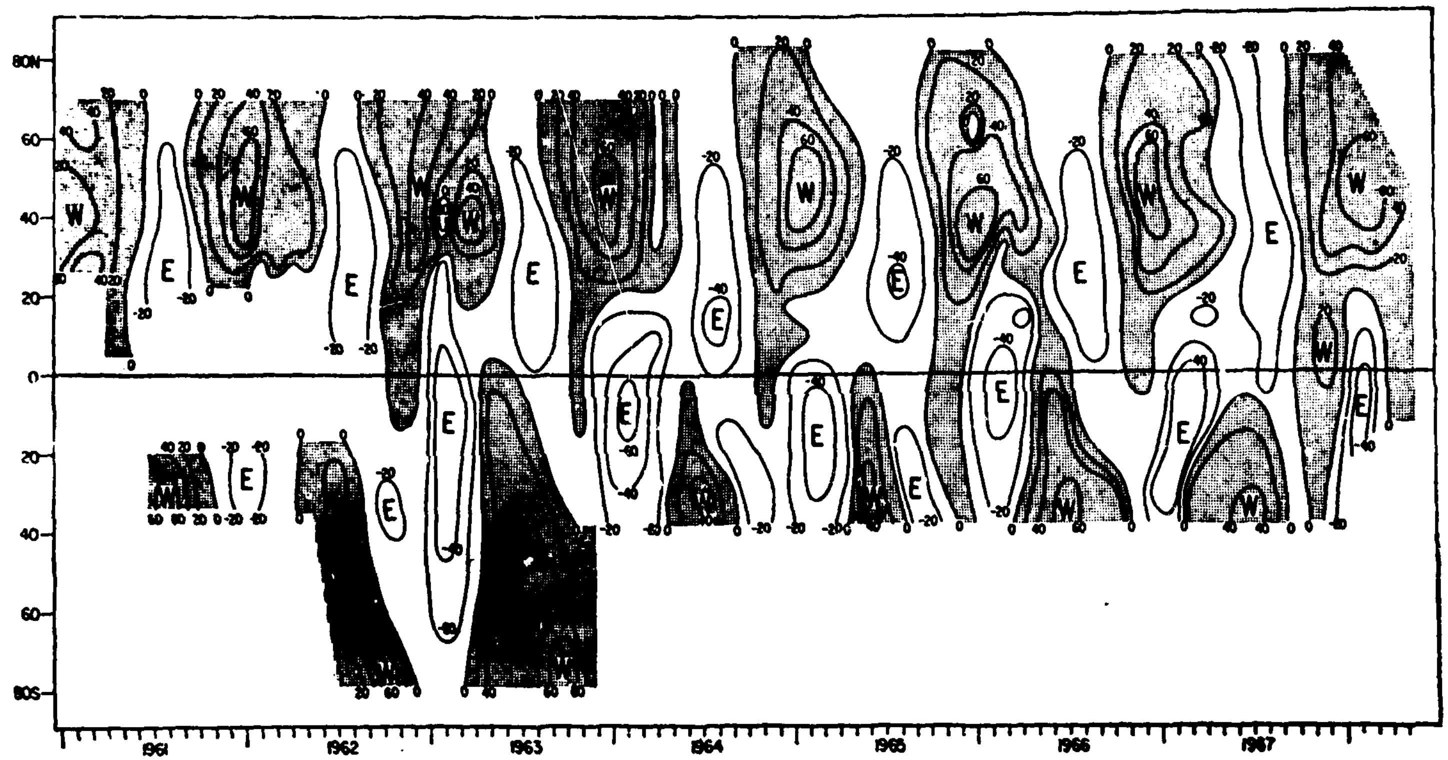


Figure 27. Latitude-Time Section of the Mean Monthly Zonal Wind at 40 km. Isotachs in m/s [118]

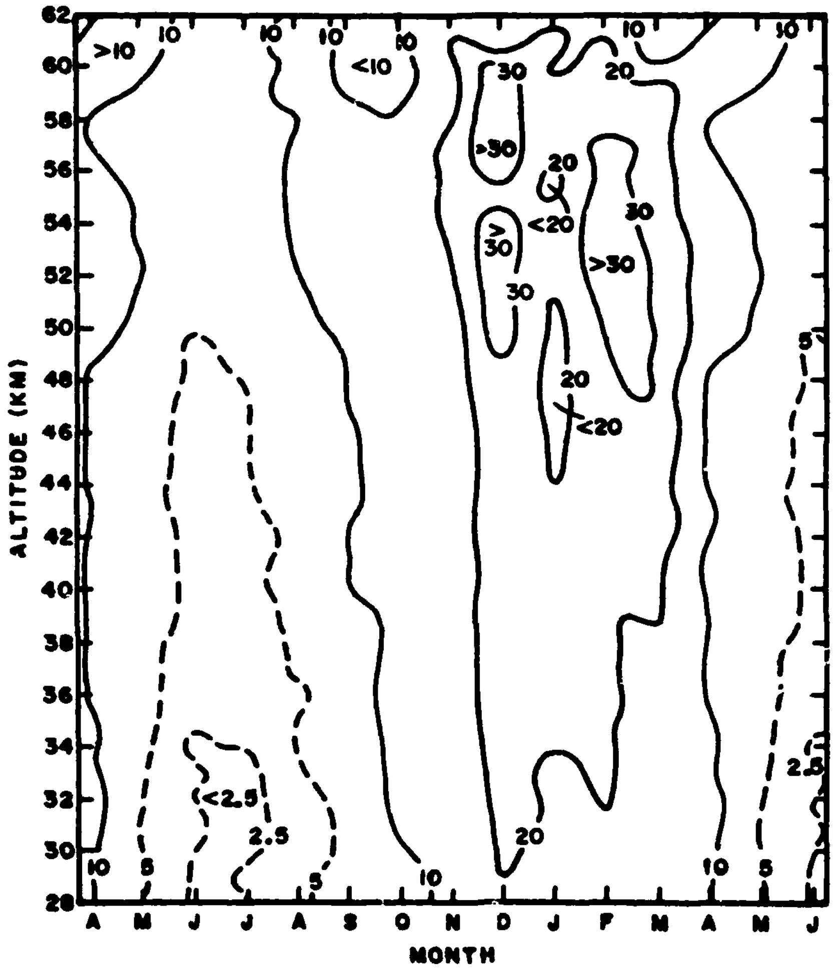


Figure 28. Time-Altitude Cross Section of the Standard Deviation of Zonal Wind About the 1961-66 Monthly Mean (m/s) for Fort Greely (64°N) [91]

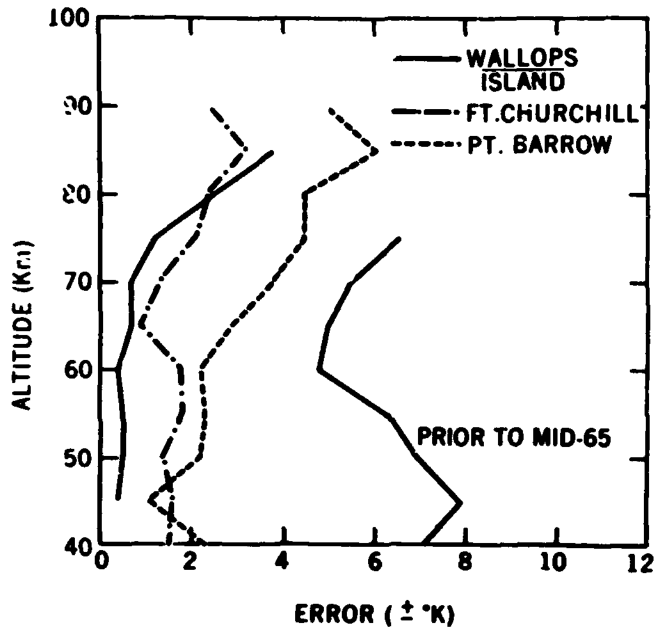


Figure 29. Average Temperature Error in Grenade Experiment. Prior to mid-1965, a smaller size of microphone array was in use [127]

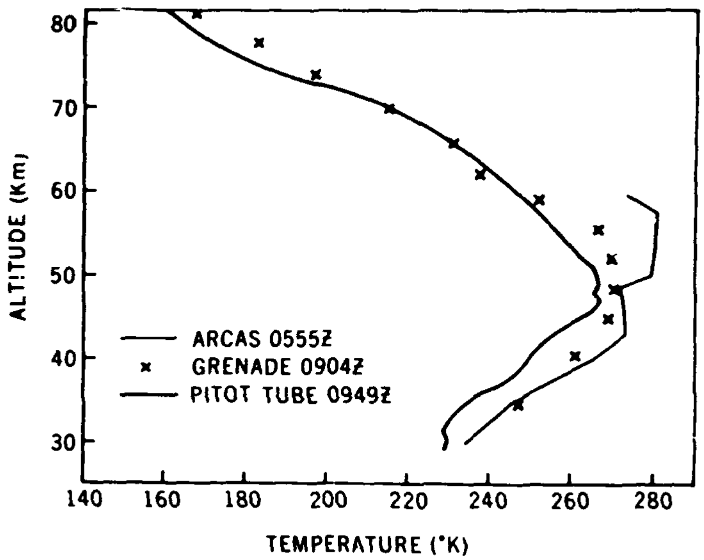
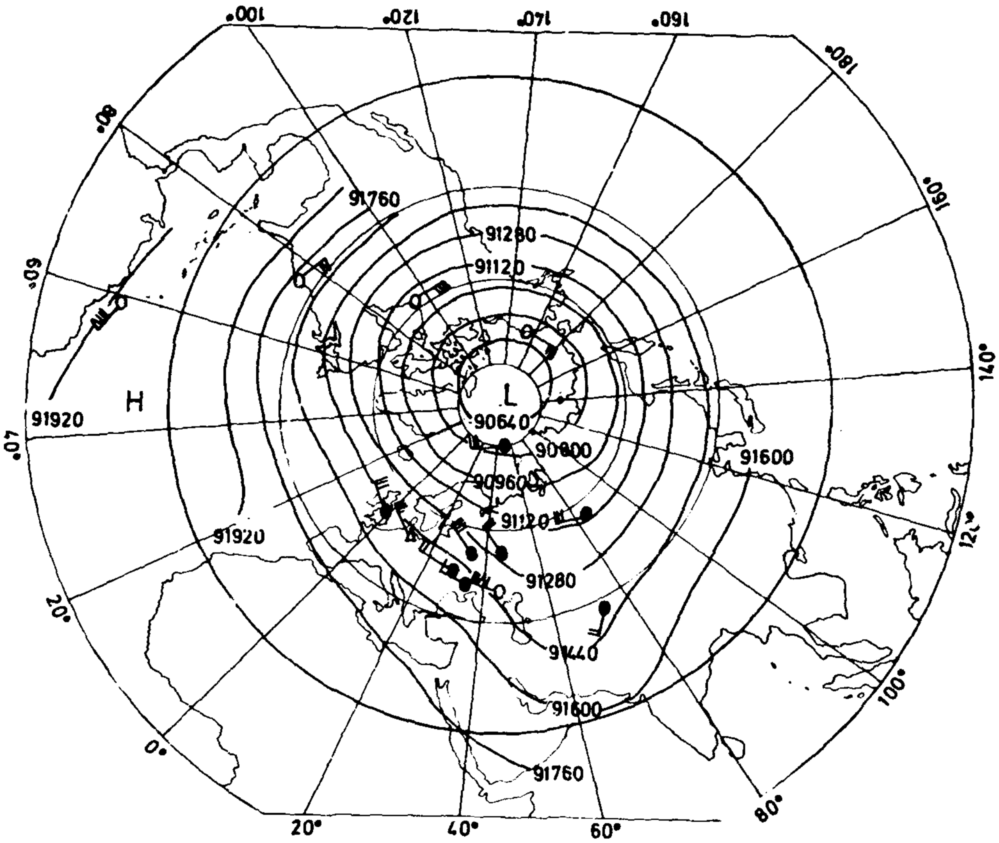


Figure 30. Comparison of Grenade, Pitot Tube and Meteorological Rocket (Arcas) Thermistor Results at Fort Churchill, 7 August 1966 [127]



Key:

● meteor trail winds, ○ rocket data, △ ionospheric drift data: 2-3 m/s, 5 m/s, 25 m/s, 50 m/s

Figure 31. Constant Pressure Chart (0.001 mb) for January [48]

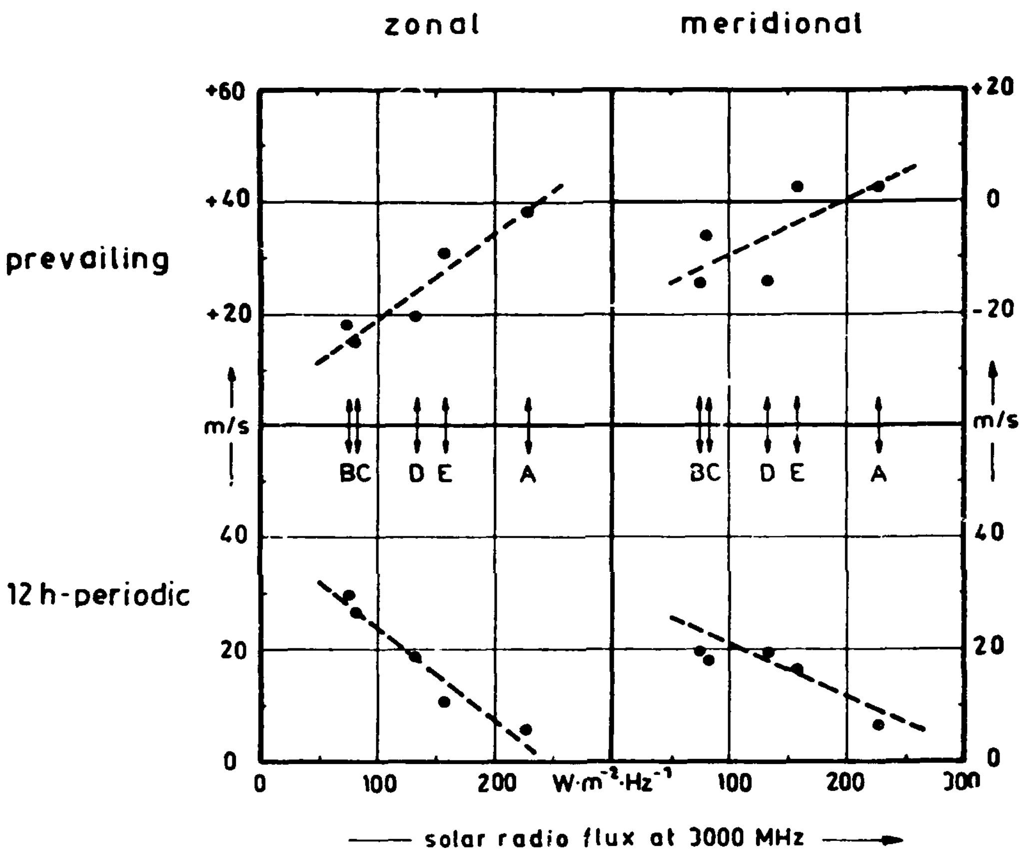


Figure 32. Correlograms of Prevailing and 12-hour Periodic Zonal and Meridional Components of the Wind in the Lower Ionosphere Over Central Europe (ordinates) Versus Mean Solar Radio Flux at 3000 MHz (abscissa) During the Winter Months of 1957-1959 (A), 1964-65 (B), 1965-66 (C), 1966-67 (D) and 1967-68 (E) [173]

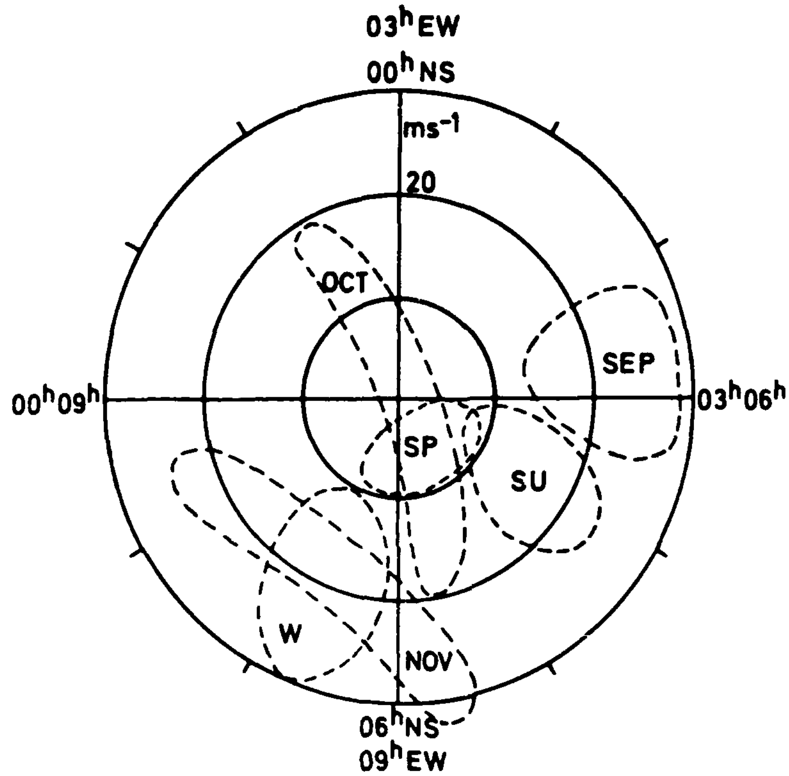


Figure 33. Idealised Pattern for the Seasonal Distribution of the Semidiurnal Tidal NS and EW Components Using Results From Three Stations Spread Over 12 years. SP: spring (March, April, May); SU: summer (June, July, August); W: winter (December, January, February) [163]

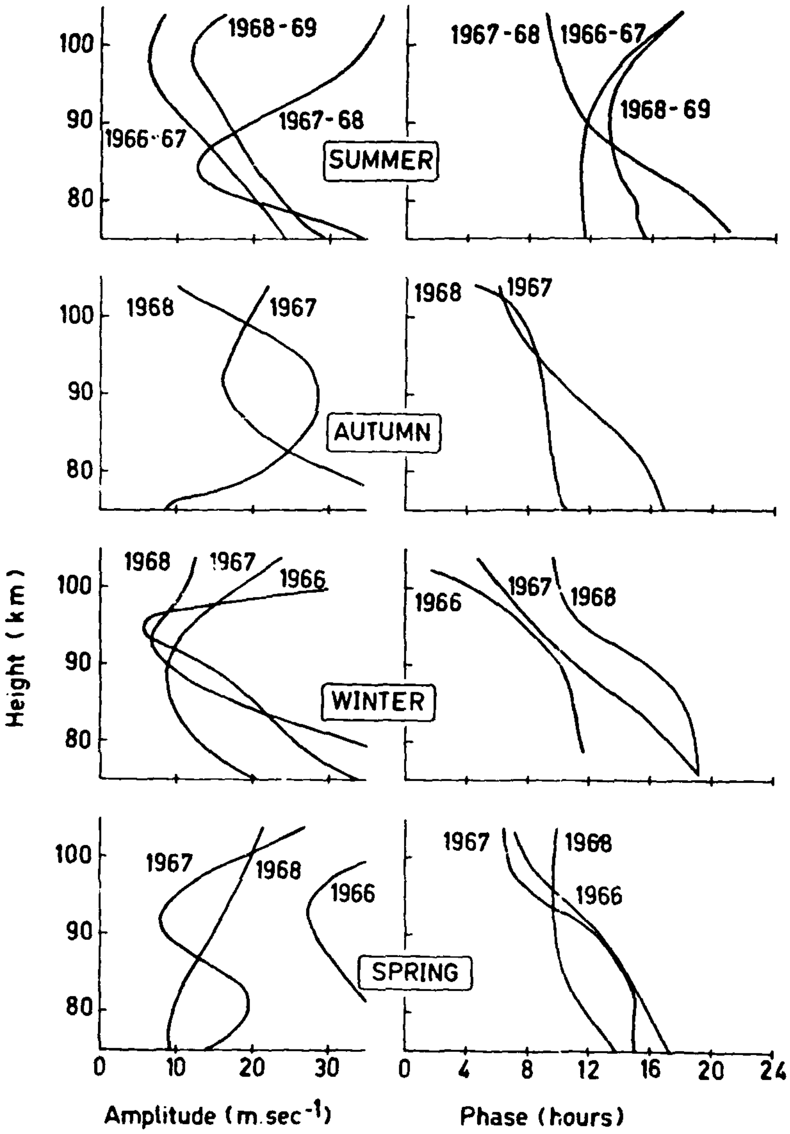


Figure 34. Seasonal Variation of Amplitude and Phase of the W-E Component of the 24-hour Wind at Adelaide (35°S). The phase is expressed by the time of maximum towards the east [157]

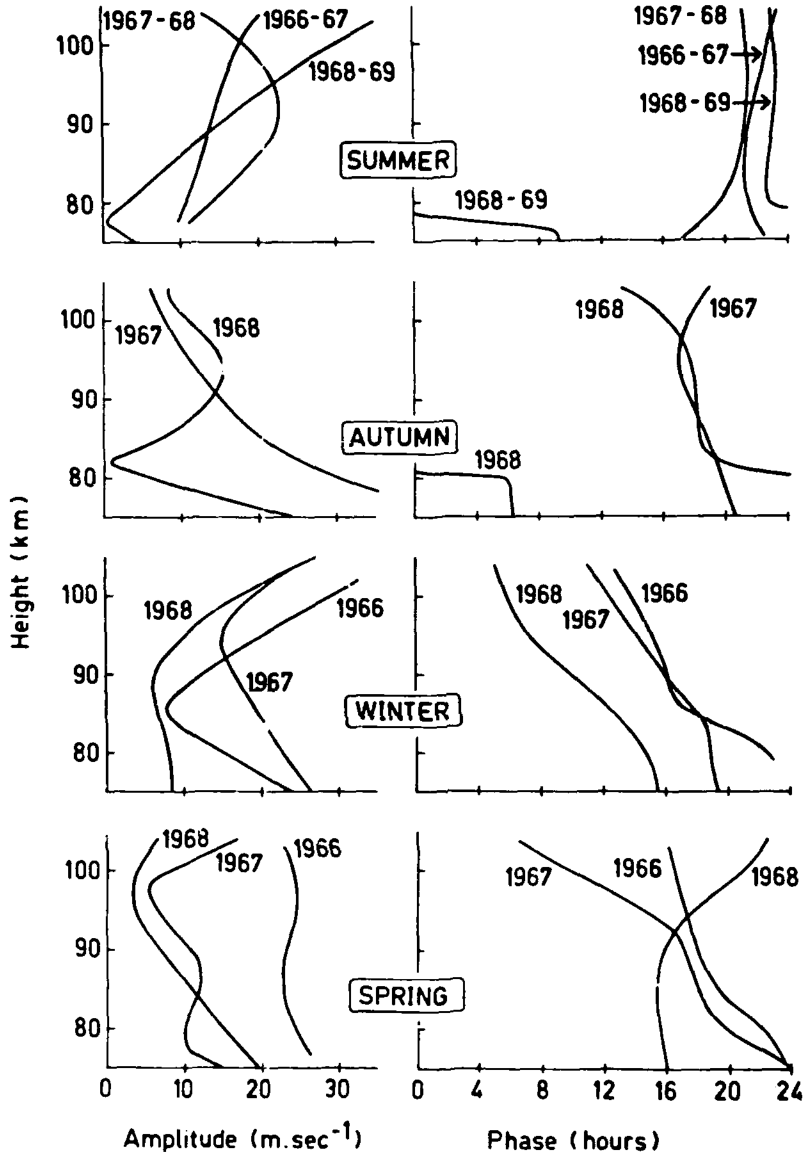


Figure 35. Seasonal Variation of the Amplitude and Phase of the S-N Component of the 24-hour Wind at Adelaide (35°S). The phase is expressed by the time of maximum towards the north [157]

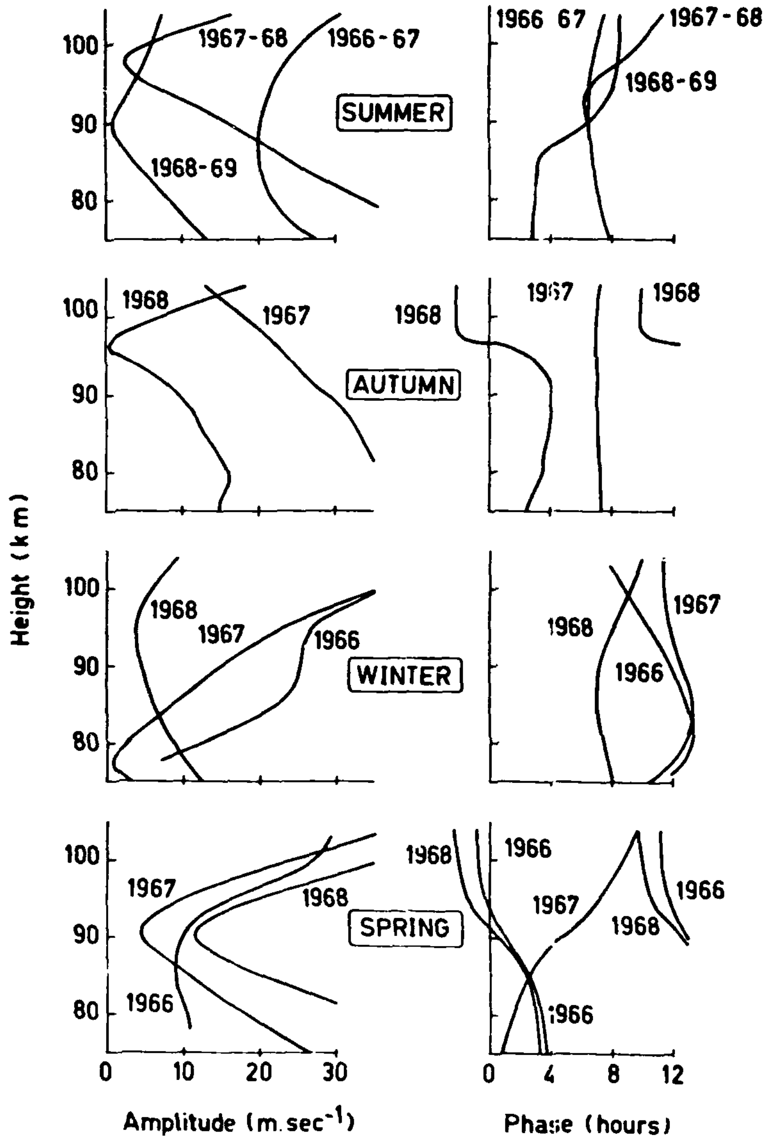


Figure 36. Seasonal Variation of the Amplitude and Phase of the W-E Component of the 12-hour Wind at Adelaide (35°S). The phase is expressed by the time of maximum towards the east [157]

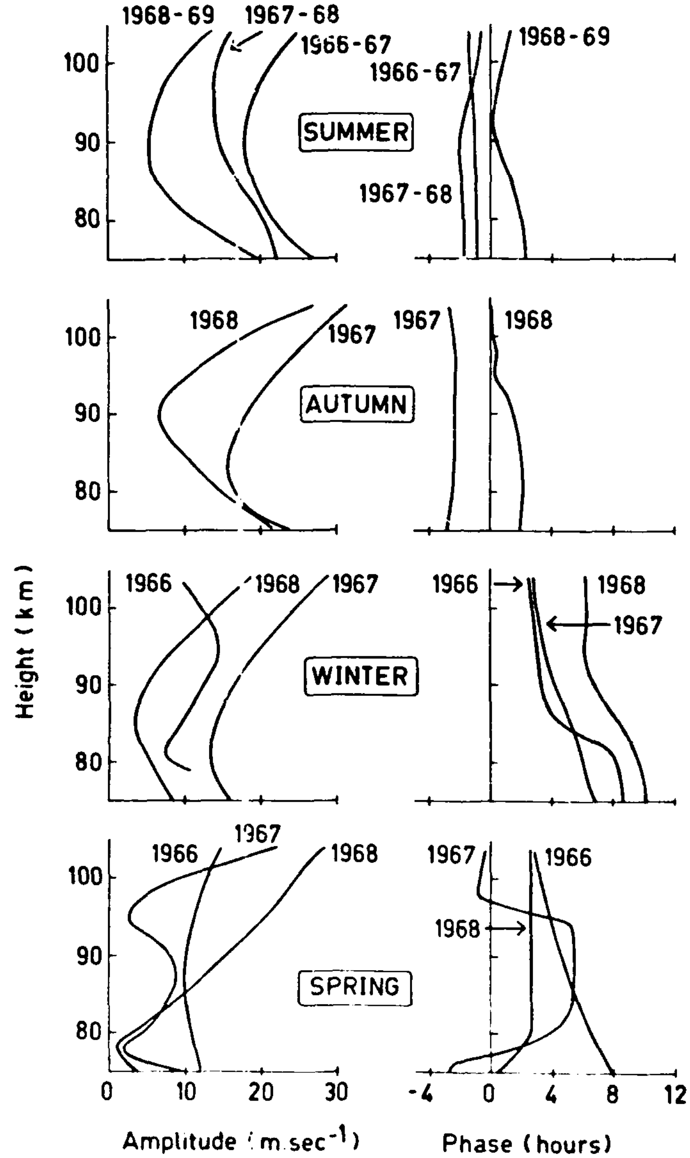


Figure 37. Seasonal Variation of the Amplitude and Phase of the S-N Component of the 12-hour Wind at Adelaide (35°S). The phase is expressed by the time of maximum towards the north [157]

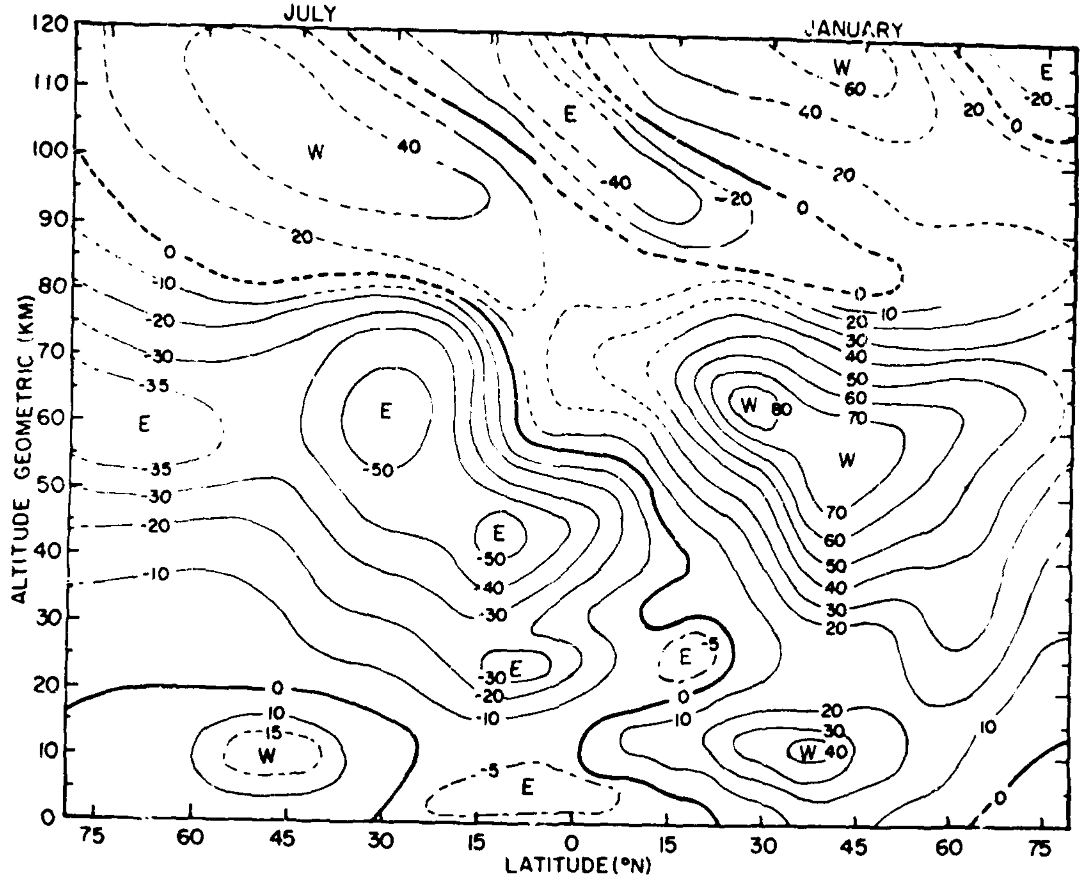


Figure 38. Mean January and July Zonal Winds to 120 km Between Equator and 75°N. This figure is from reference [182] with revised contours for the altitudes 85-120 km from the equator to 30°N [183]

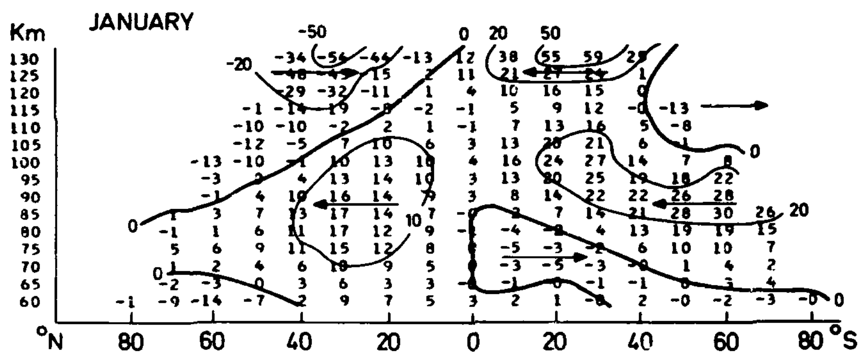
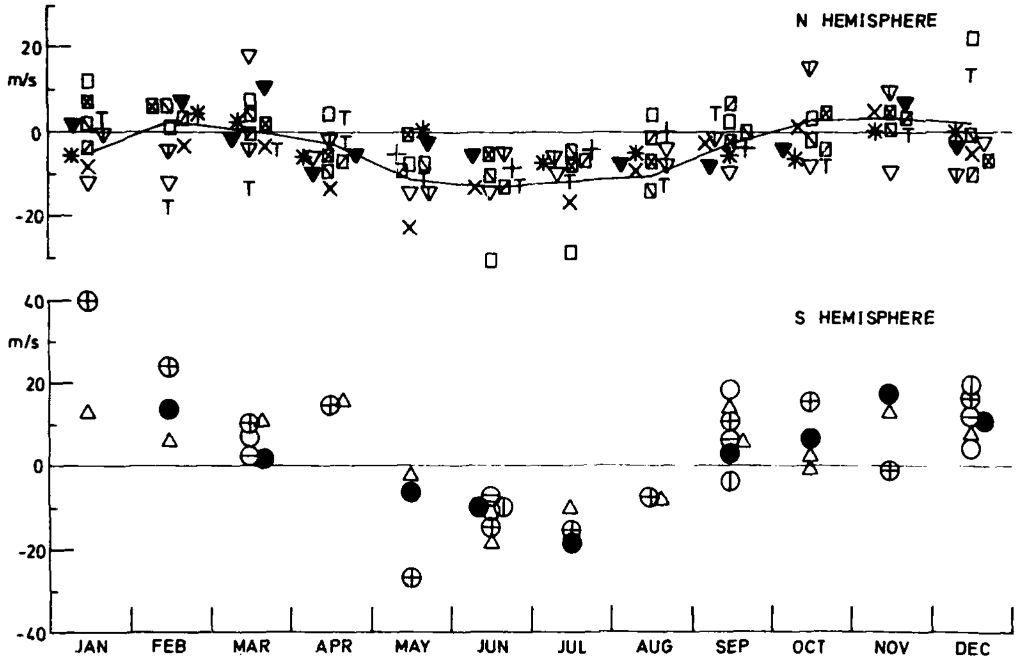


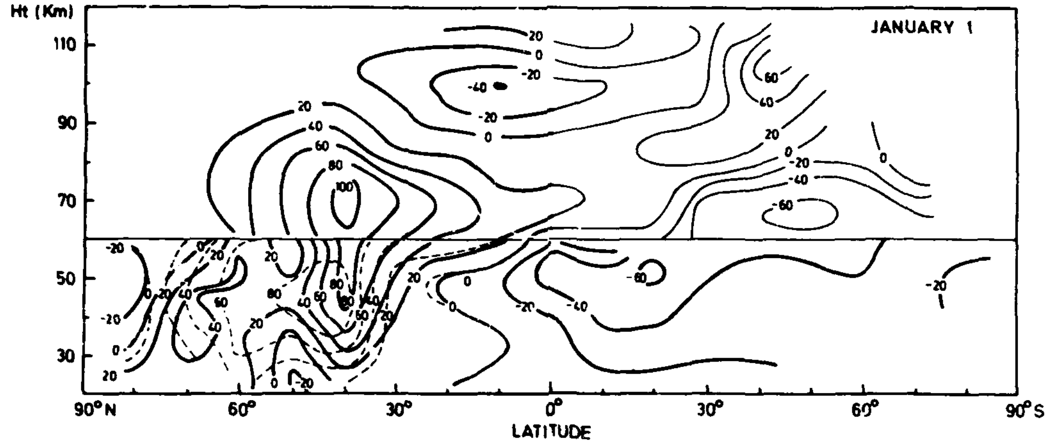
Figure 39. S-N Winds in m/s for 1 January. S. Hemisphere values are based mainly on N. Hemisphere data with a 6-month change of date [155]

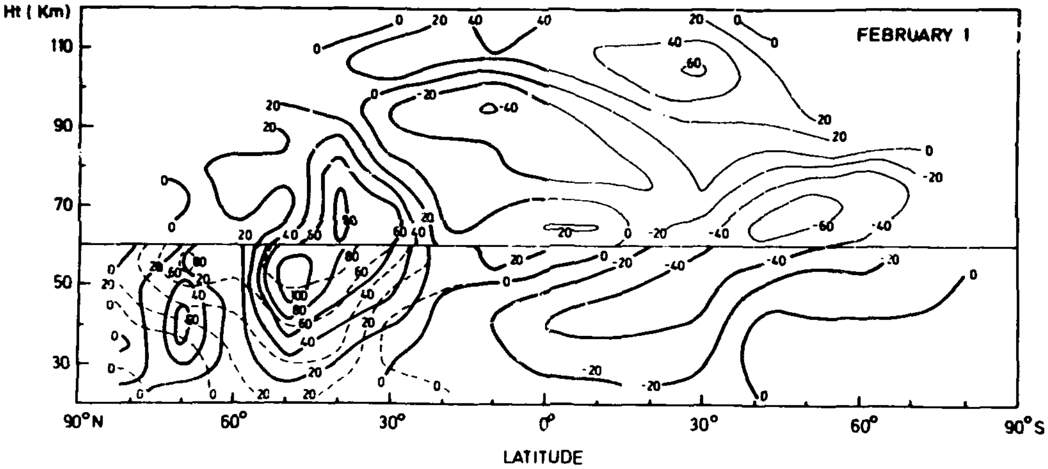


Key:

Adelaide (35°S, 139°E): ● 1952-1953 [185]; ⊕ December 1960-December 1961 [156]; ⦶ 1966, ⊖ 1967, ○ 1968 [157].
Heiss Is. (81°N, 58°E): T March 1967-April 1968 [177].
Jodrell Bank (53°N, 2°W): —— (continuous line) 1953-1958 average [162].
Kazan (56°N, 49°E): ✳ March 1964-February 1965 [166].
Kharkov (50°N, 36°E): □ April 1960-March 1961 [158]; ⧅ March 1962-March 1963 [159]; ⧄ 1964, ⊠ 1965 [160].
Molodezhnaya (67°S, 46°E): △ September 1967-October 1968 [177].
Obninsk (55°N, 36°E): ▽ 1964, ⩢ 1965 [160]; ▼ March 1967-April 1968 [165].
Palo Alto (37°N, 122°W); + May-September 1967 [134].
Sheffield (53°N, 1°W): X August 1964-July 1965 [163].

Figure 40. Seasonal Variation of the Prevailing S-N Wind Component at Radar Meteor Stations (95 km Altitude)

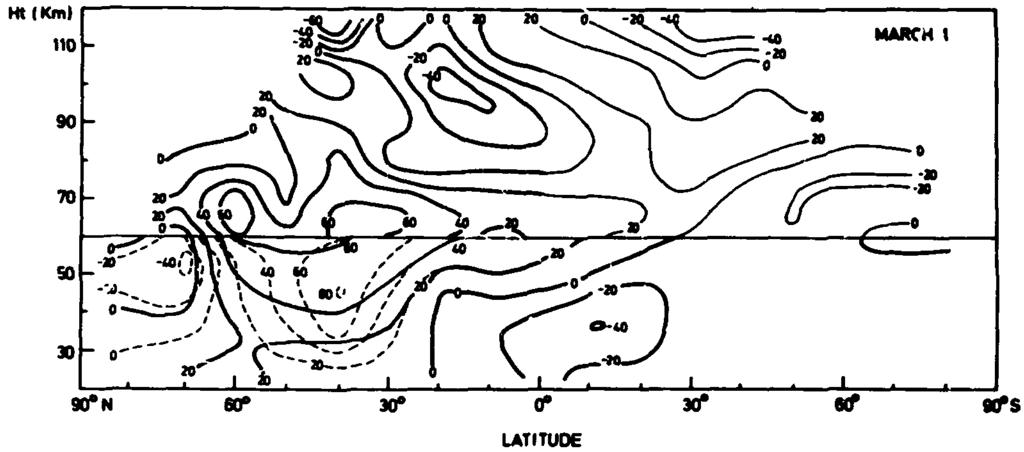


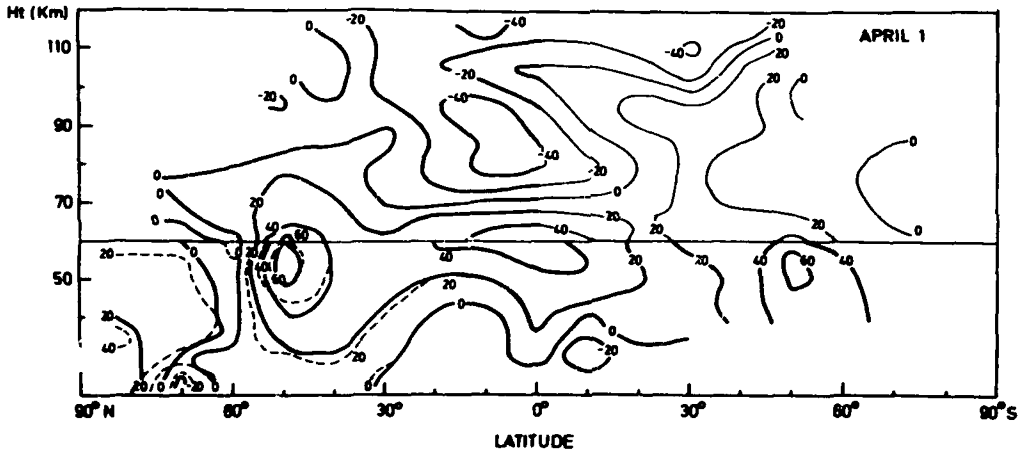


Key:

—— based on N. American data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April. At other times of the year or at latitudes south of 25°N or at heights above 60 km the same line denotes data from all longitudes; - - - based on European/W. Asian data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April; —— same model as latitudes N with a 6-month change of date.

Figure 41. Zonal Wind Components in m/s During Months of January - December. Positive winds are to the east

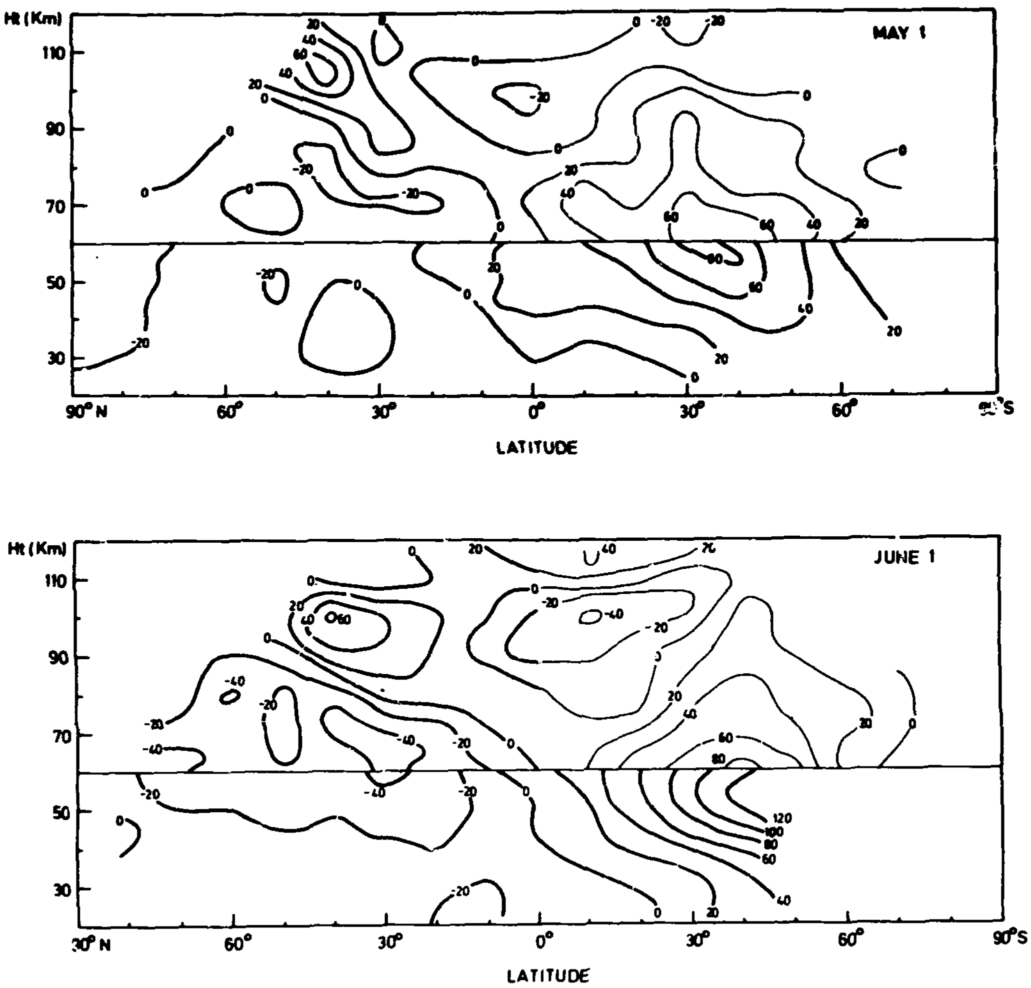




Key:

—— based on N. American data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April. At other times of the year or at latitudes south of 25°N or at heights above 60 km the same line denotes data from all longitudes; - - - based on European/W. Asian data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April; —— same model as latitudes N with a 6-month change of date.

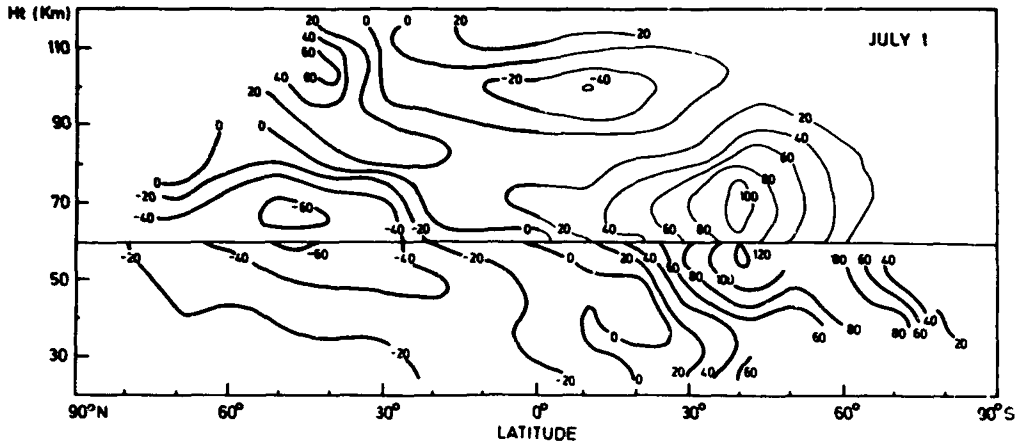
Figure 41 (Contd.). Zonal Wind Components in m/s During Months of January - December. Positive winds are to the east

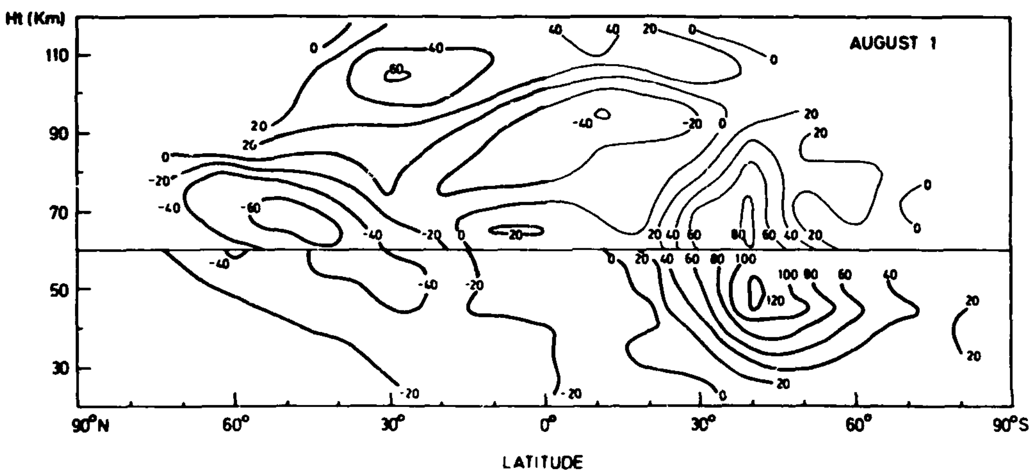


Key:

—— based on N. American data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April. At other times of the year or at latitudes south of 25°N or at heights above 60 km the same line denotes data from all longitudes; - - - based on European/W. Asian data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April; —— same model as latitudes N with a 6-month change of date.

Figure 41 (Contd.). Zonal Wind Components in m/s During Months of January - December. Positive winds are to the east

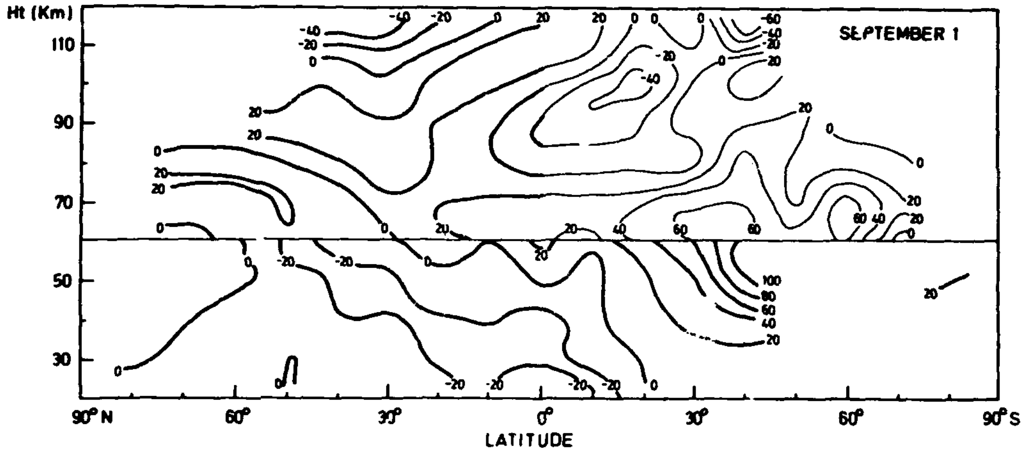


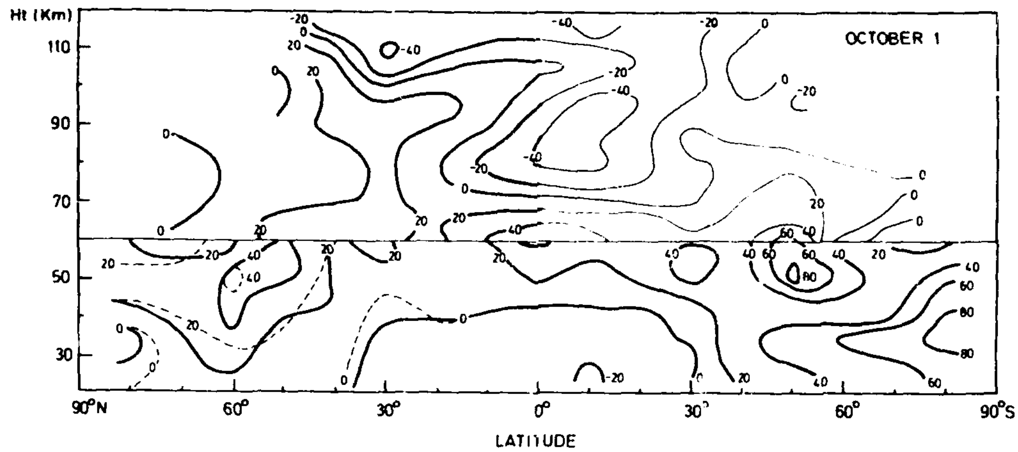


Key:

—— based on N. American data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April. At other times of the year or at latitudes south of 25°N or at heights above 60 km the same line denotes data from all longitudes; - - - based on European/W. Asian data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April; —— same model as latitudes N with a 6-month change of date.

Figure 41 (Contd.). Zonal Wind Components in m/s During Months of January - December. Positive winds are to the east

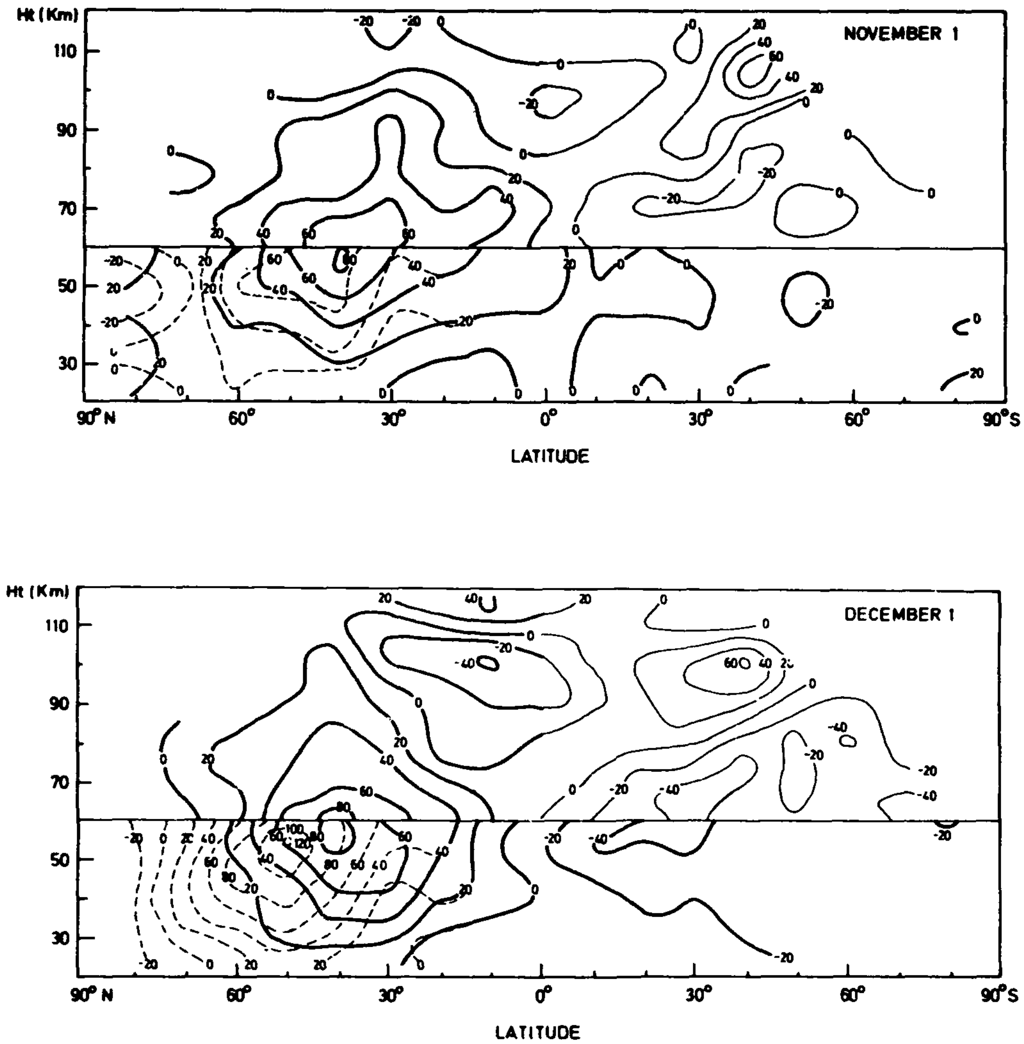




Key:

—— based on N. American data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April. At other times of the year or at latitudes south of 25°N or at heights above 60 km the same line denotes data from all longitudes; --- based on European/W. Asian data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April; —— same model as latitudes N with a 6-month change of date.

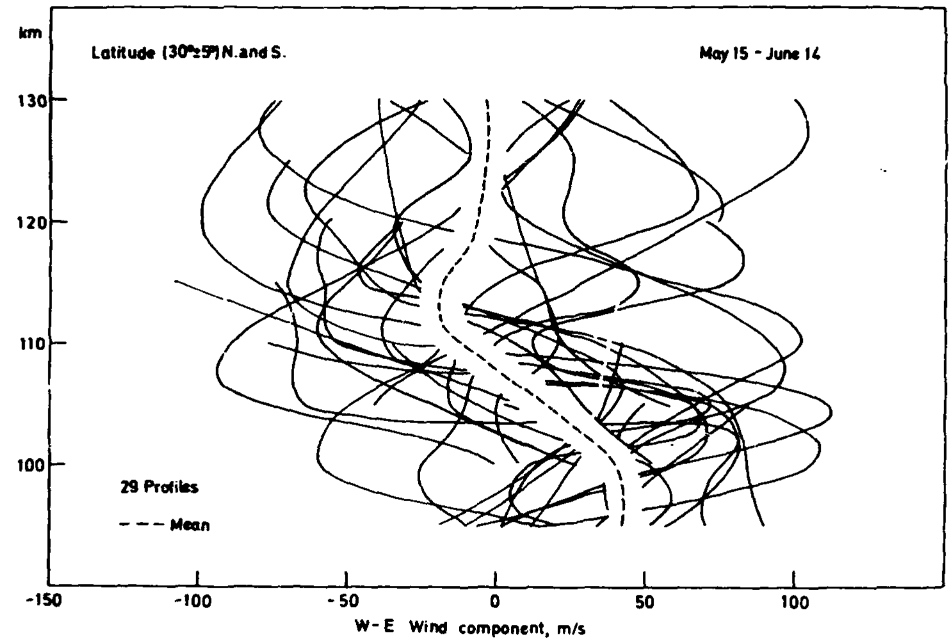
Figure 41 (Contd.). Zonal Wind Components in m/s During Months of January - December. Positive winds are to the east



Key:

—— based on N. American data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April. At other times of the year or at latitudes south of 25°N or at heights above 60 km the same line denotes data from all longitudes; --- based on European/W. Asian data below 60 km (Table 1) for sites north of 25°N and months 1 October to 1 April; —— same model as latitudes N with a 6-month change of date.

Figure 41 (Contd.). Zonal Wind Components in m/s During Months of January - December. Positive winds are to the east



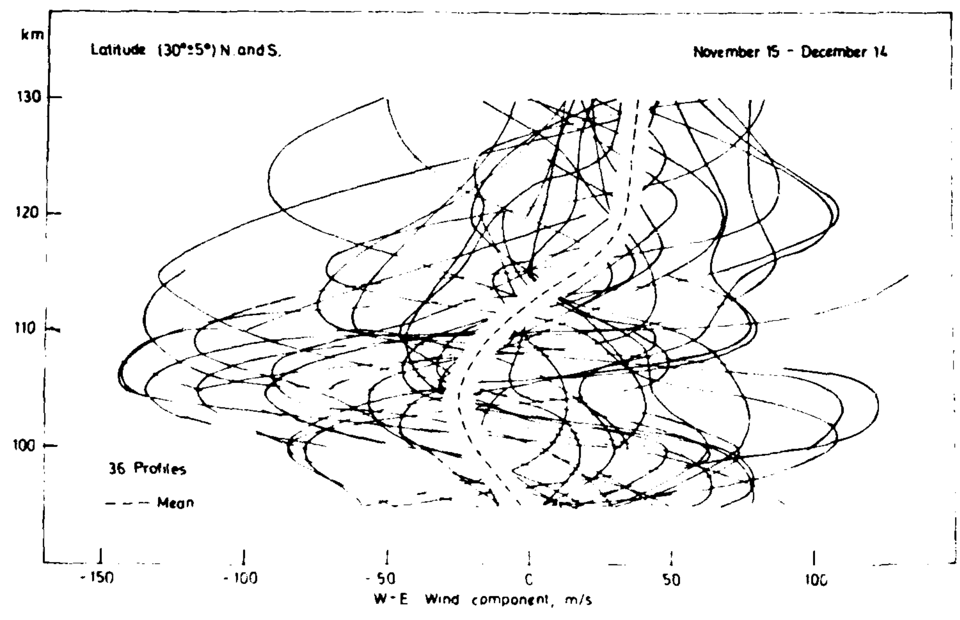


Figure 42. Zonal Wind Profiles From Chemical Trail Experiments at 30 (±5)$^{\circ}$ Latitude N and S for Launchings Held 15 May - 14 June and 15 November - 14 December. Data from the S. Hemisphere are shifted by 6 months to correspond in season. The dashed lines are from Tables 10a and b

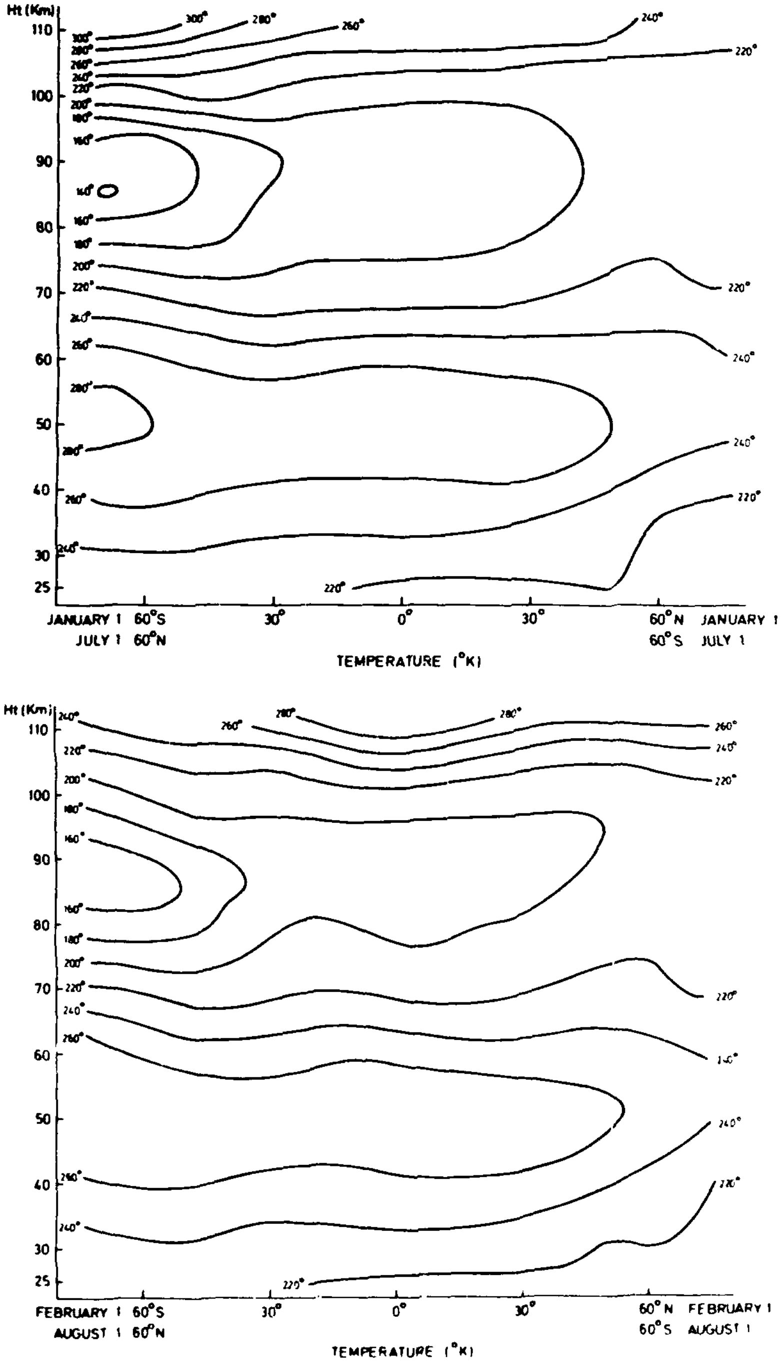
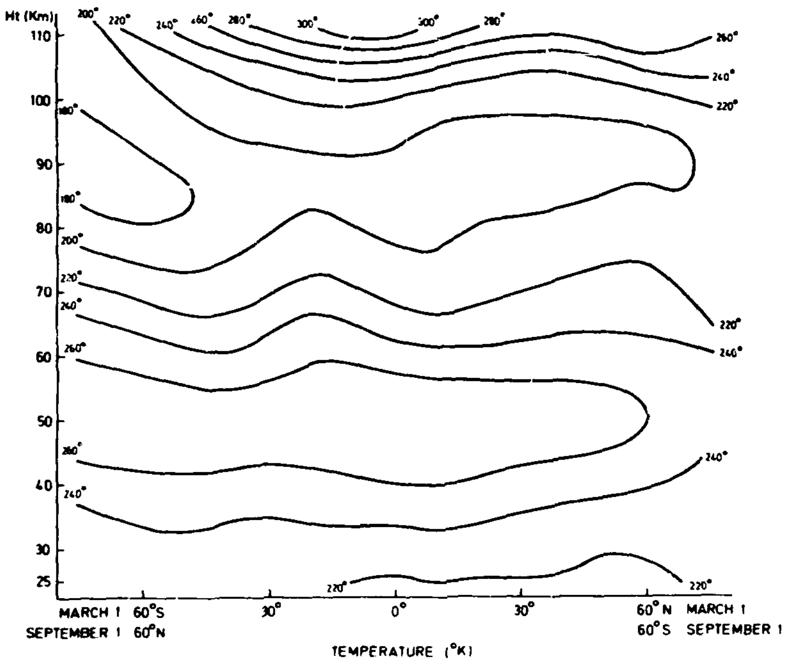


Figure 43. Temperatures in ^{O}K. Data from S. and N. Hemispheres have been combined with a 6-month change of date



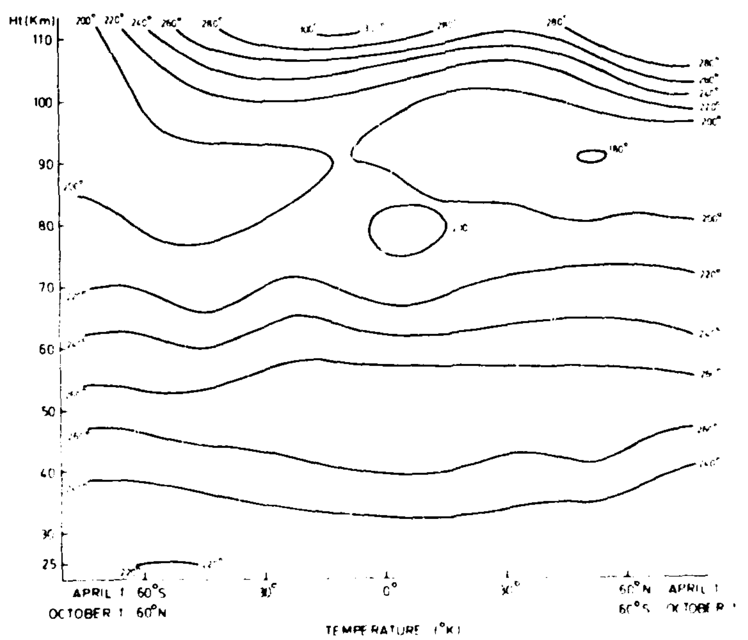


Figure 43 (Contd.). Temperatures in °K. Data from S. and N. Hemispheres have been combined with a 6-month change of date

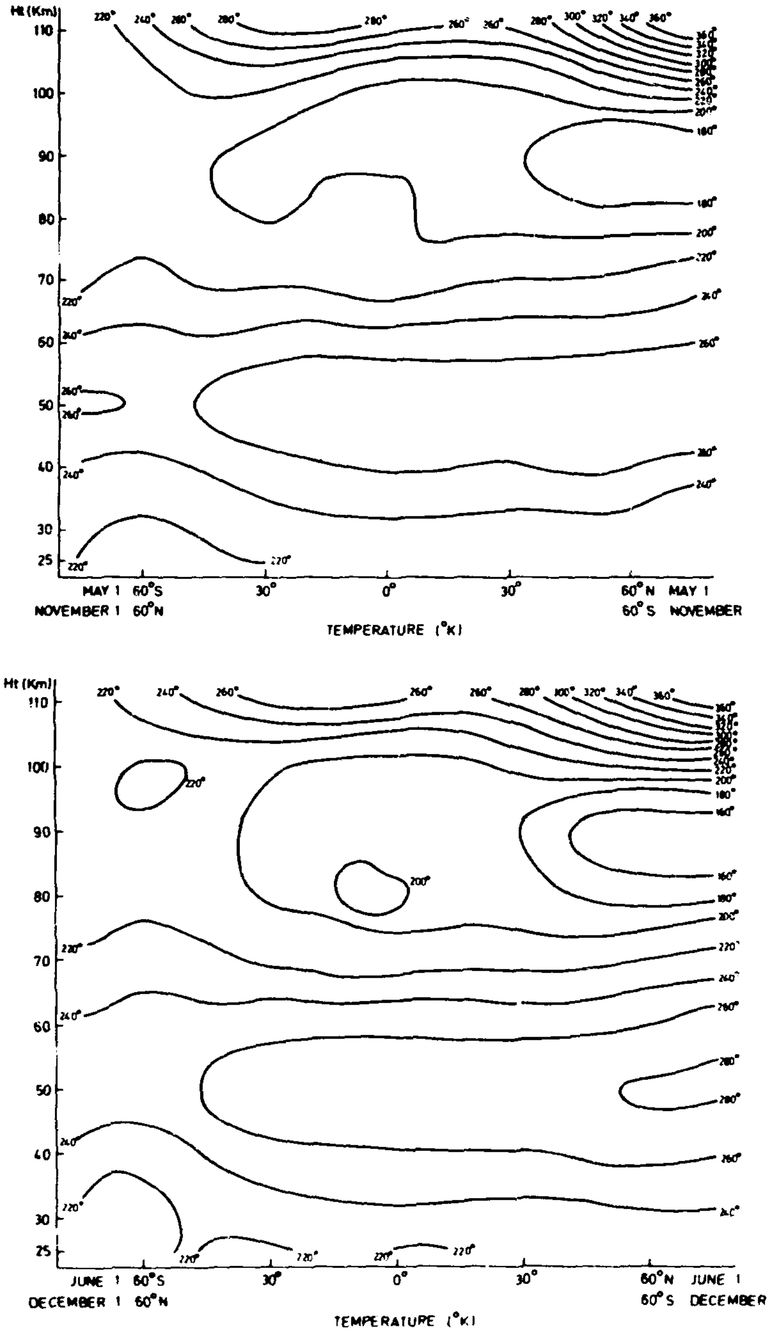


Figure 43 (Contd.). Temperatures in ^{o}K. Data from S. and N. Hemispheres have been combined with a 6-month change of date

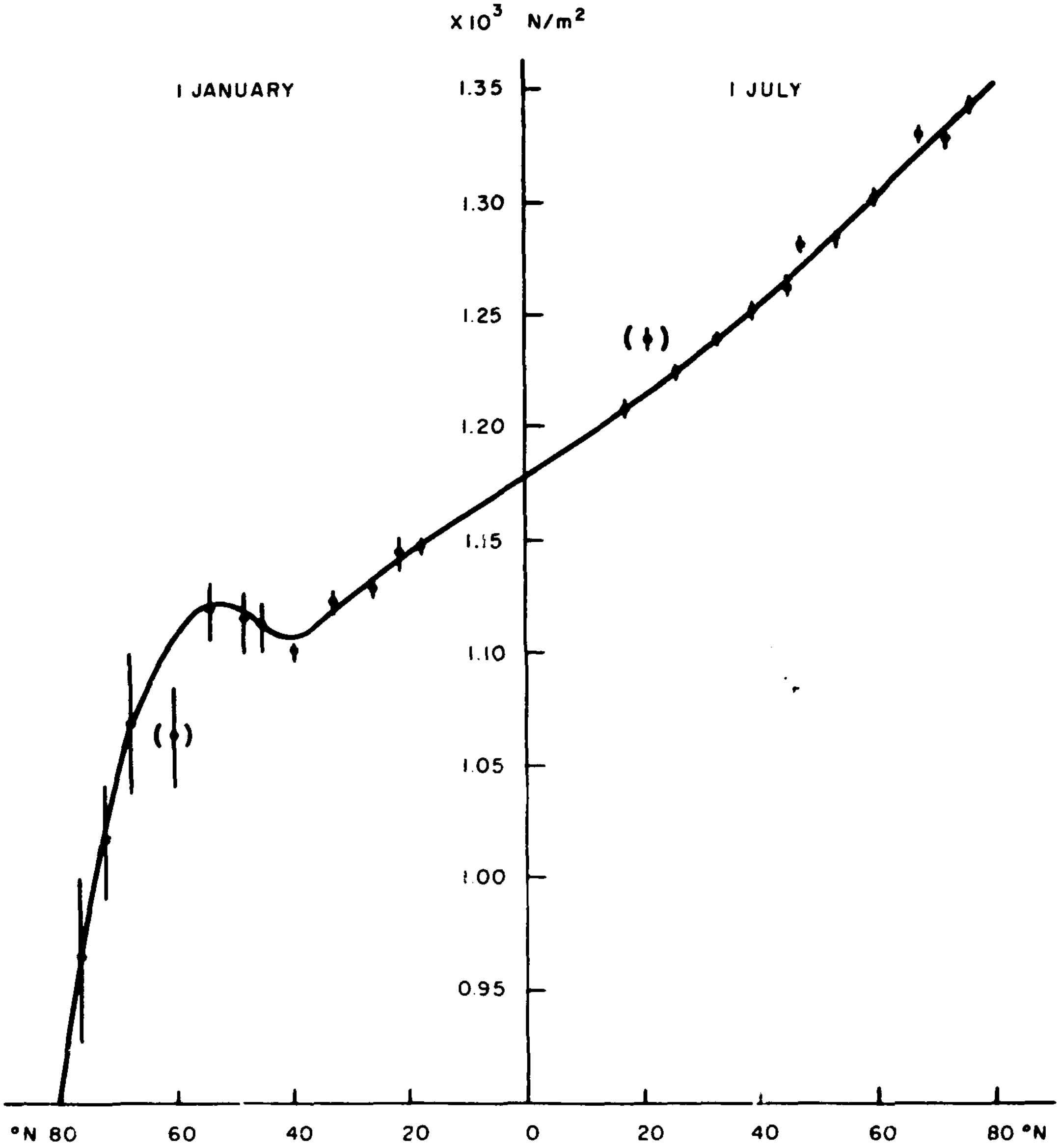


Figure 44. Pressure at 30 km Derived for 1 January and 1 July From Data Obtained at the Stations Listed in Table 23

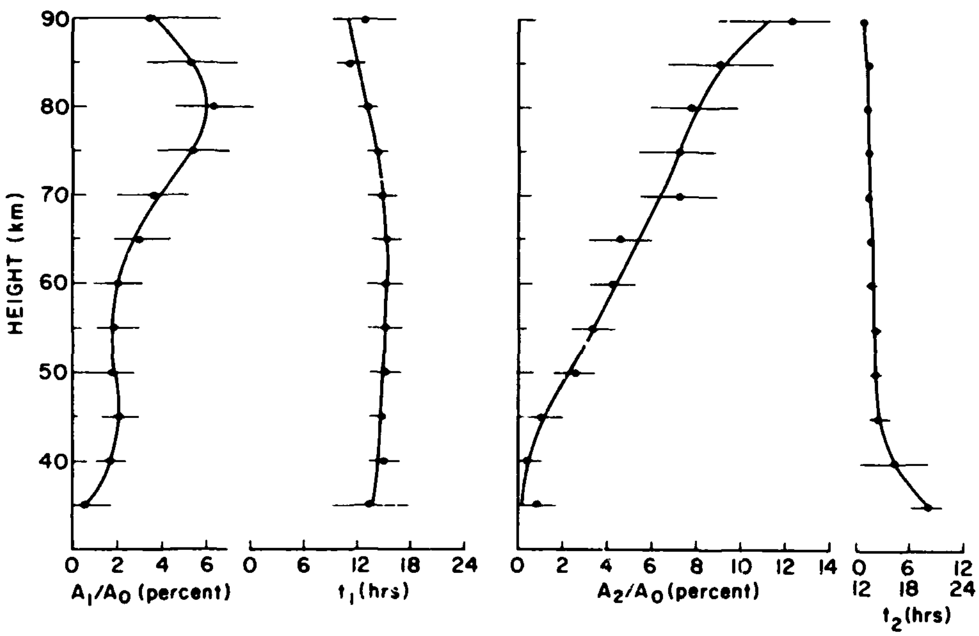


Figure 45. Relative Amplitudes A_1/A_0, A_2/A_0 of the Diurnal and Semi-Diurnal Pressure Oscillations at Low Latitude and Their Respective Times of Maximum Value t_1, t_2. The values of log A_0 (Newtons/m^2) at heights 35(5)90 km are: 2.760, 2.466, 2.184, 1.910, 1.635, 1.355, 1.057, 0.733, 0.379, 0.011, $\bar{1}$ 644, $\bar{1}$ 268

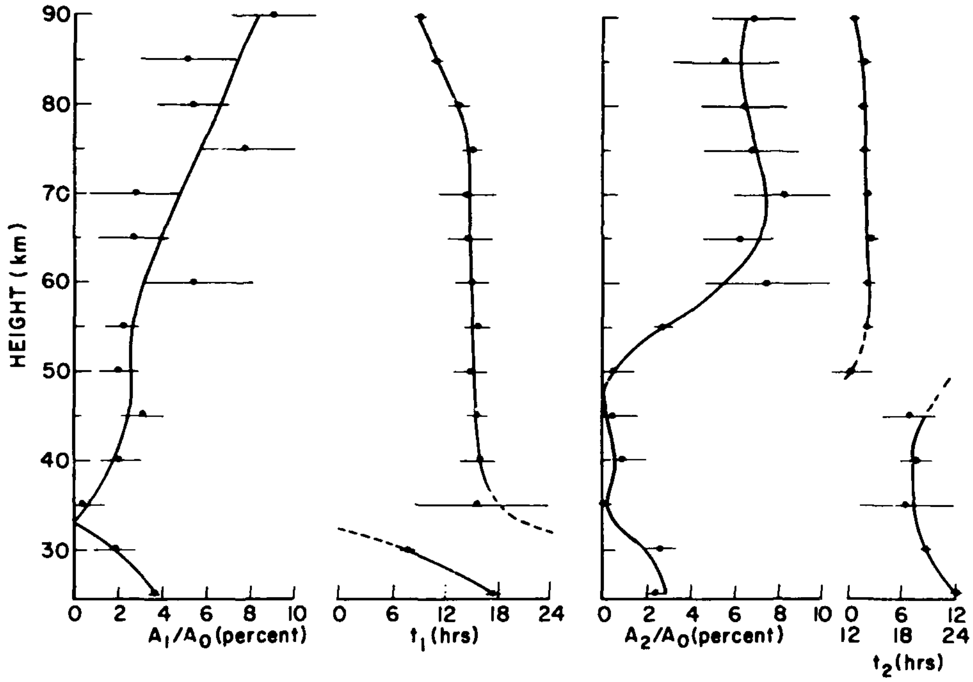
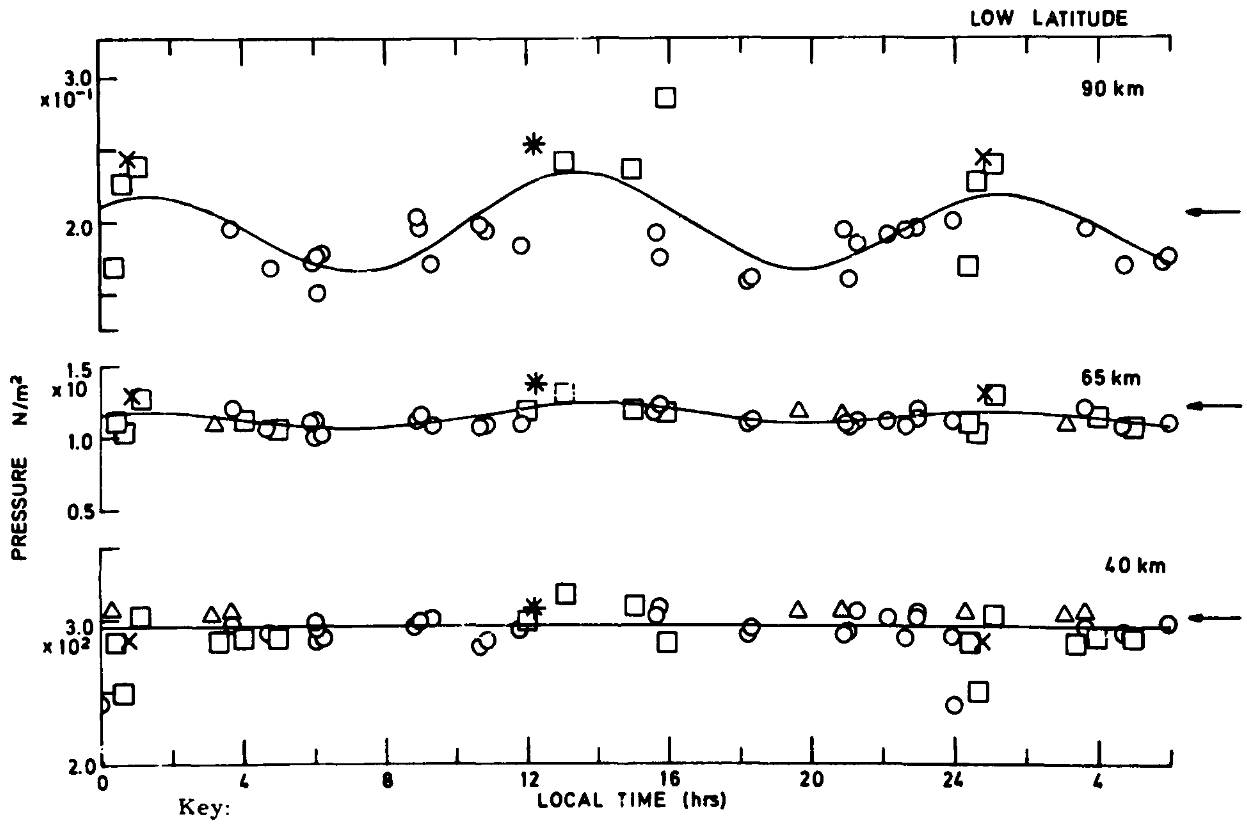


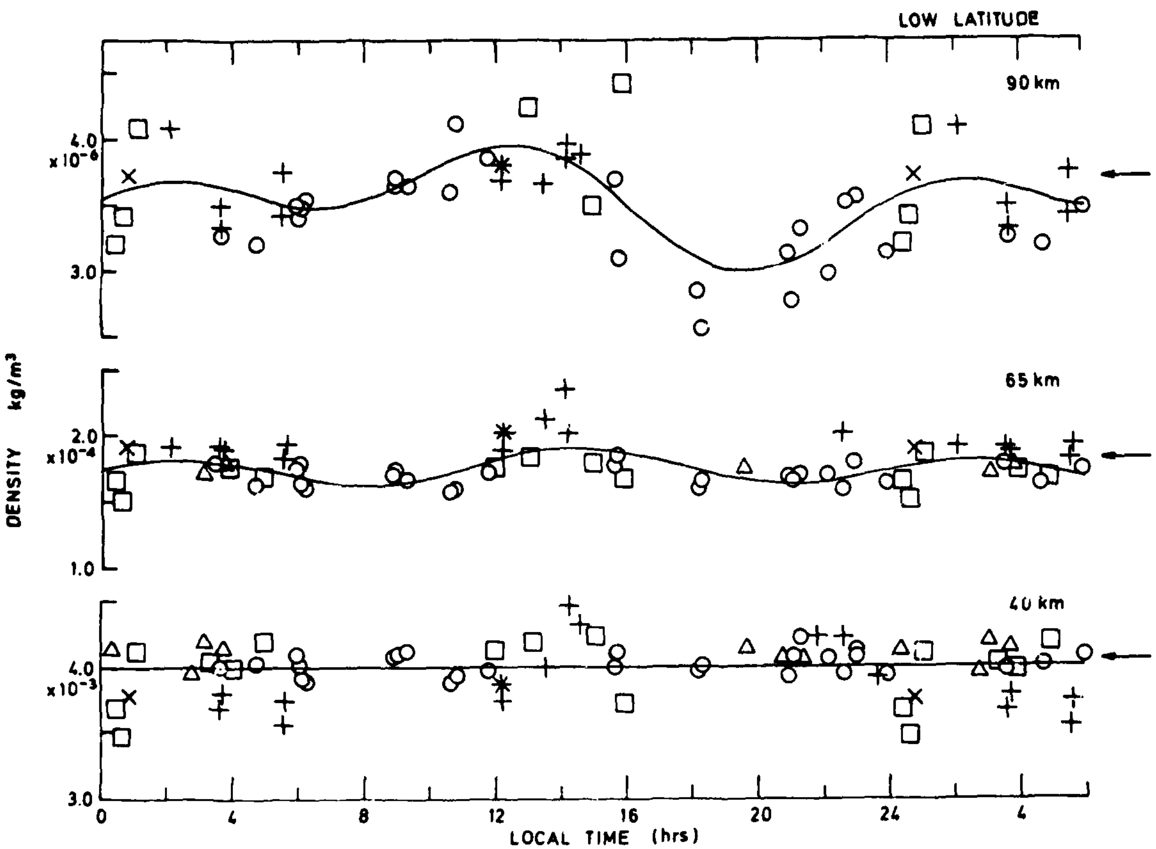
Figure 46. Relative Amplitudes A_1/A_0, A_2/A_0 of the Diurnal and Semi-Diurnal Density Oscillations at Low Latitude and Their Respective Times of Maximum Value t_1, t_2. The values of log A_0 (kg/m^3) at heights 25 (5) 90 km are: $\bar{2}.592$, $\bar{2}.255$, $\bar{3}.918$, $\bar{3}.603$, $\bar{3}.304$, $\bar{3}.023$, $\bar{4}.756$, $\bar{4}.505$, $\bar{4}.243$, $\bar{5}.962$, $\bar{5}.632$, $\bar{5}.267$, $\bar{6}.898$, $\bar{6}.540$



Key:

←Mean Annual Value From Tables 24b or 26b; ○ Natal (6°S) [22, 23, 56]; □ Ascension Is. (8°S) [21, 55, 56]; ⊤ Kwajalein (9°N) [190]; △ Guam (13°N) [21, 190]; × Ship (1°S) [55]; ✱ Ship (0°) [55]; ◻ Ascension Is. MRN Monthly Mean Values [15]

Figure 47. The Diurnal Variation of Pressure and Density at Low Latitude. Data points are compared with least-squares curves of the form in Eq. (4) at 65 and 90 km. At 40 km the mean value of the data points is plotted



Key: ←— Mean Annual Value From Tables 24b or 26b; ○ Natal ($6^{o}S$) [22, 23, 56]; □ Ascension Is. ($8^{o}S$) [21, 55, 56]; + Kwajalein ($9^{o}N$) [190]; △ Guam ($13^{o}N$) [21, 190]; × Ship ($1^{o}S$) [55]; ✱ Ship (0^{o}) [55]; ◐ Ascension Is. *MRN Monthly Mean Values* [15]

Figure 47 (Contd.). The Diurnal Variation of Pressure and Density at Low-Latitude. Data points are compared with least-squares curves of the form in Eq. (4) at 65 and 90 km. At 40 km the mean value of the data points is plotted

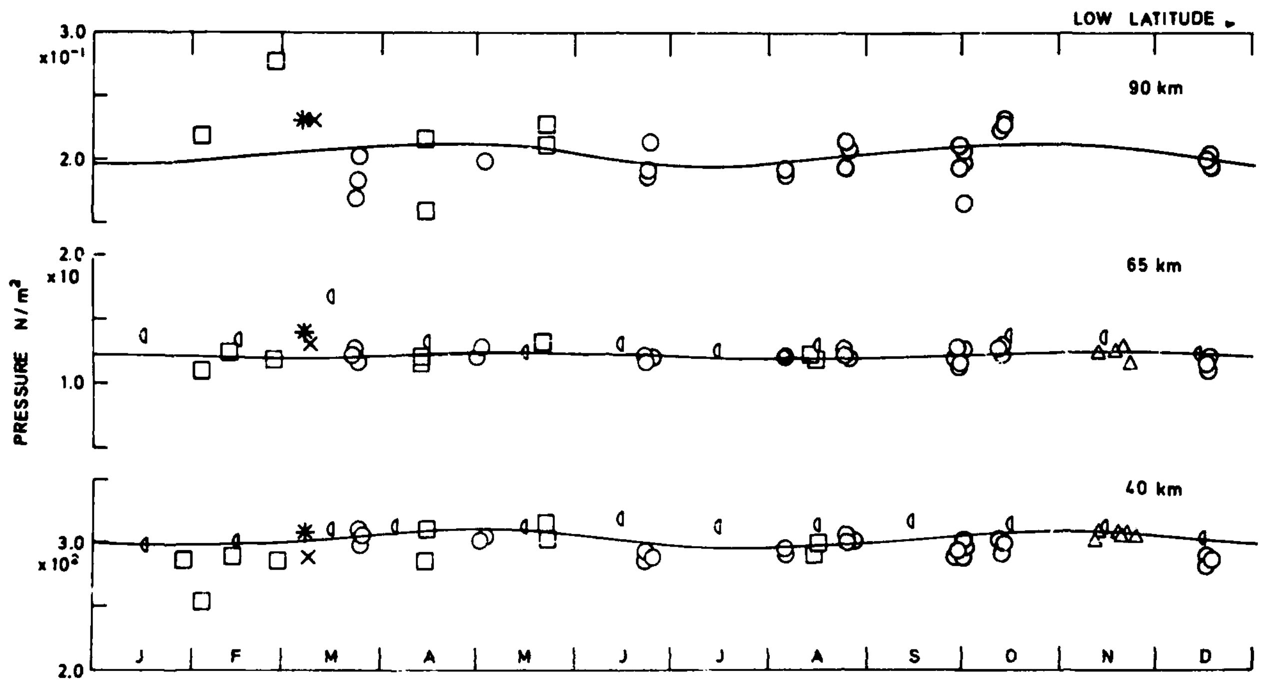


Figure 48. The Seasonal Variation of Low-latitude Pressure and Density Data After Correcting 65 and 90 km Values for the Diurnal Variation by Reference to Figure 47. The data so corrected are compared with 0° latitude curves from Tables 24b and 26b. See Figure 47 for the key to symbols

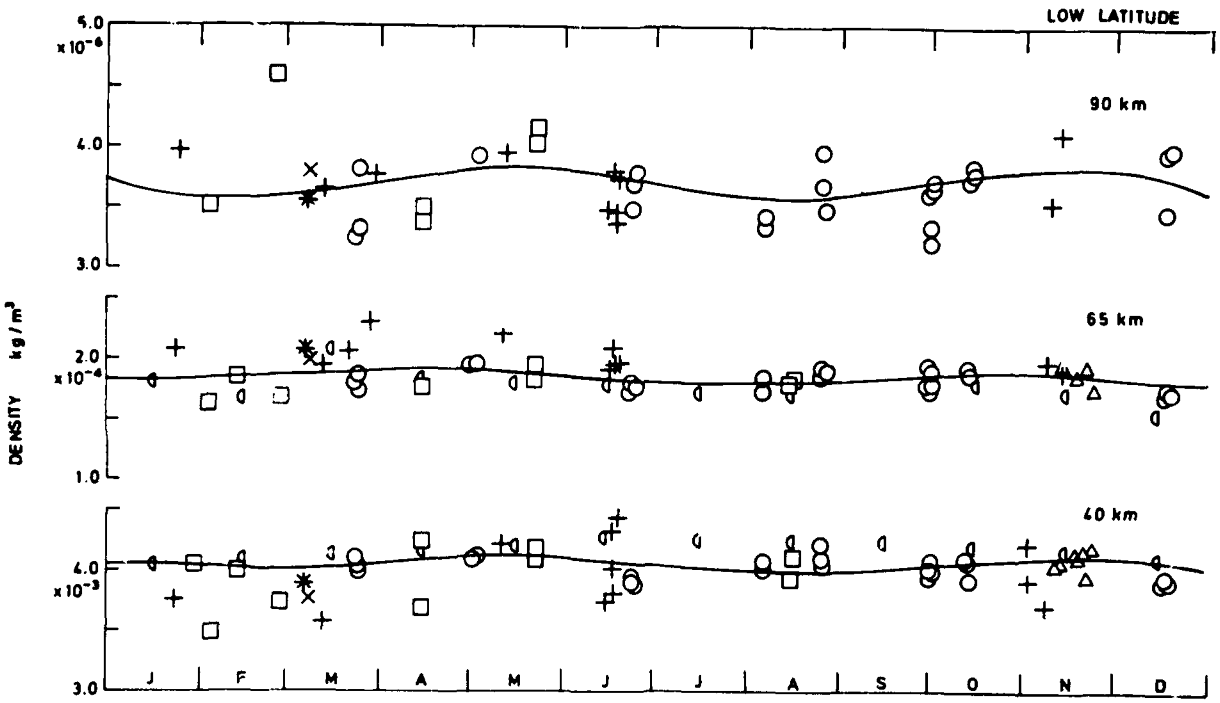
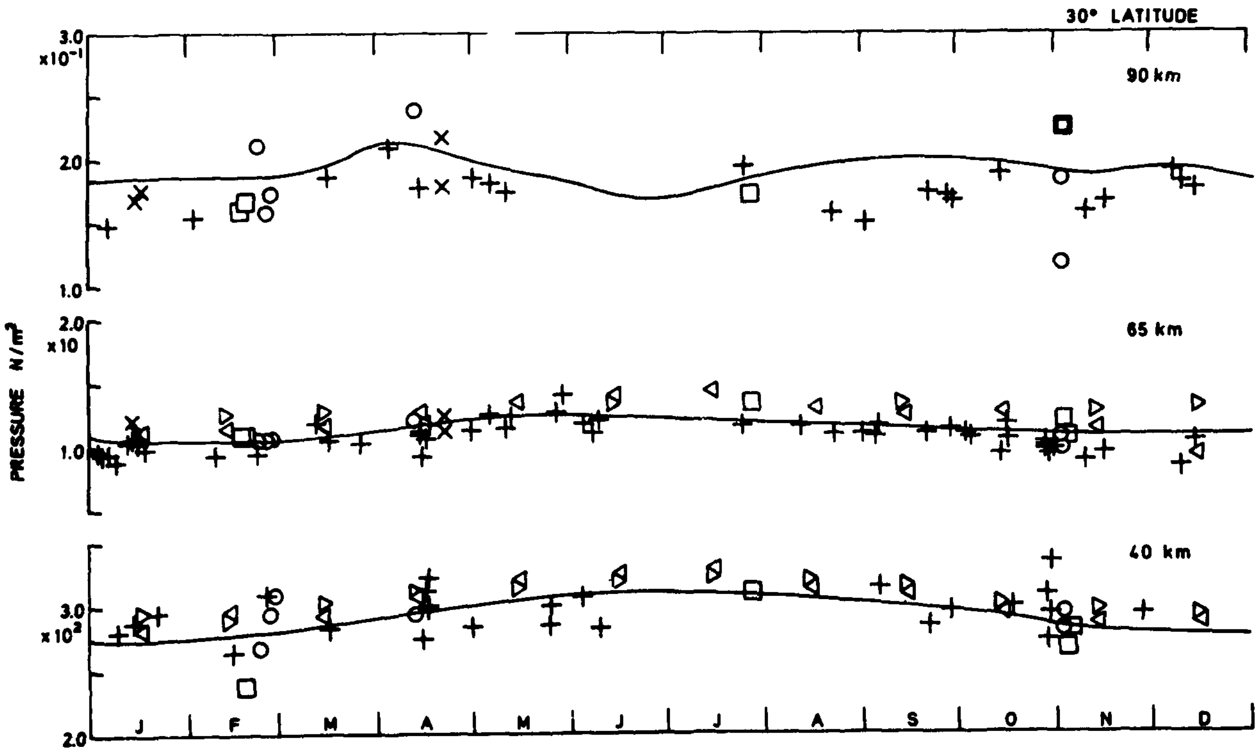


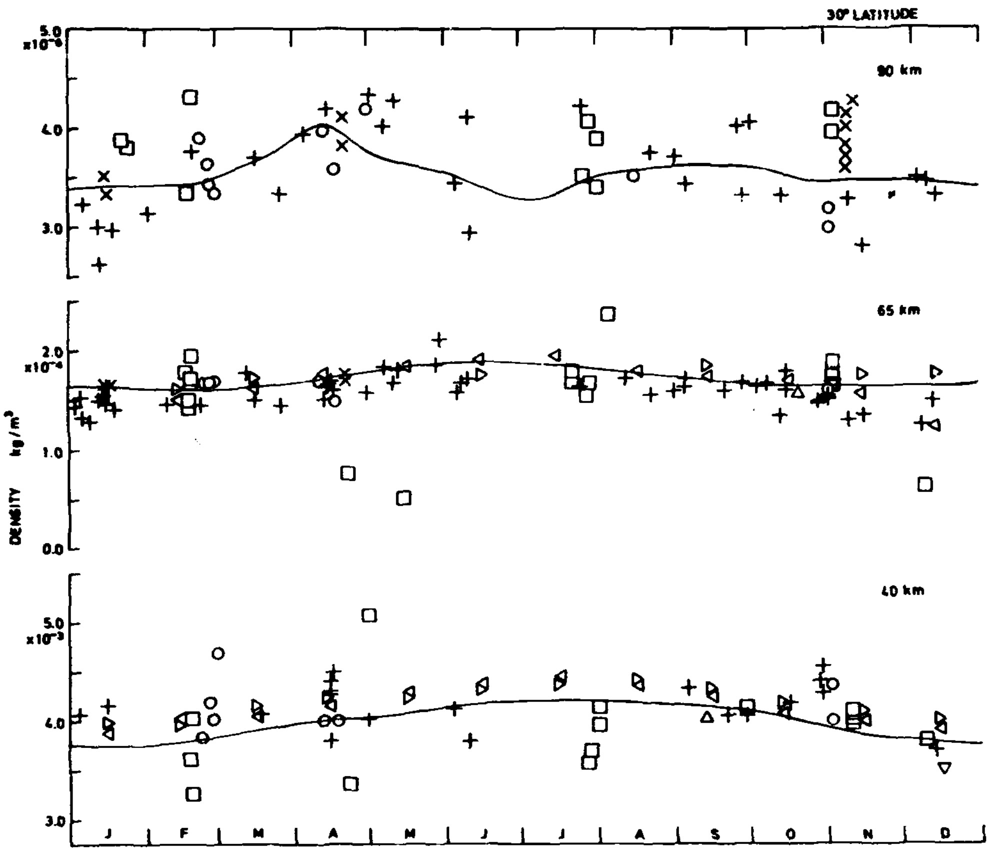
Figure 48 (Contd.). The Seasonal Variation of Low-latitude Pressure and Density Data After Correcting 65 and 90 km Values for the Diurnal Variation by Reference to Figure 47. The data so corrected are compared with 0° latitude curves from Tables 24b and 26b. See Figure 47 for the key to symbols



Key:

× Carnarvon (25°S) [110, 191, 192]; + Woomera (31°S) [43, 44, 45, 46, 47, 191, 193, 194, 195, 196, 197, 198]; ○ Eglin (30°N) [49, 50, 51, 190]; □ White Sands (32°N) [52, 53, 190]; ◁ White Sands MRN monthly mean values [15]; ▷ Cape Kennedy (28°N) MRN monthly mean values [15]; △ Holloman (33°N) [190]; ▽ Point Mugu (34°N) [190]

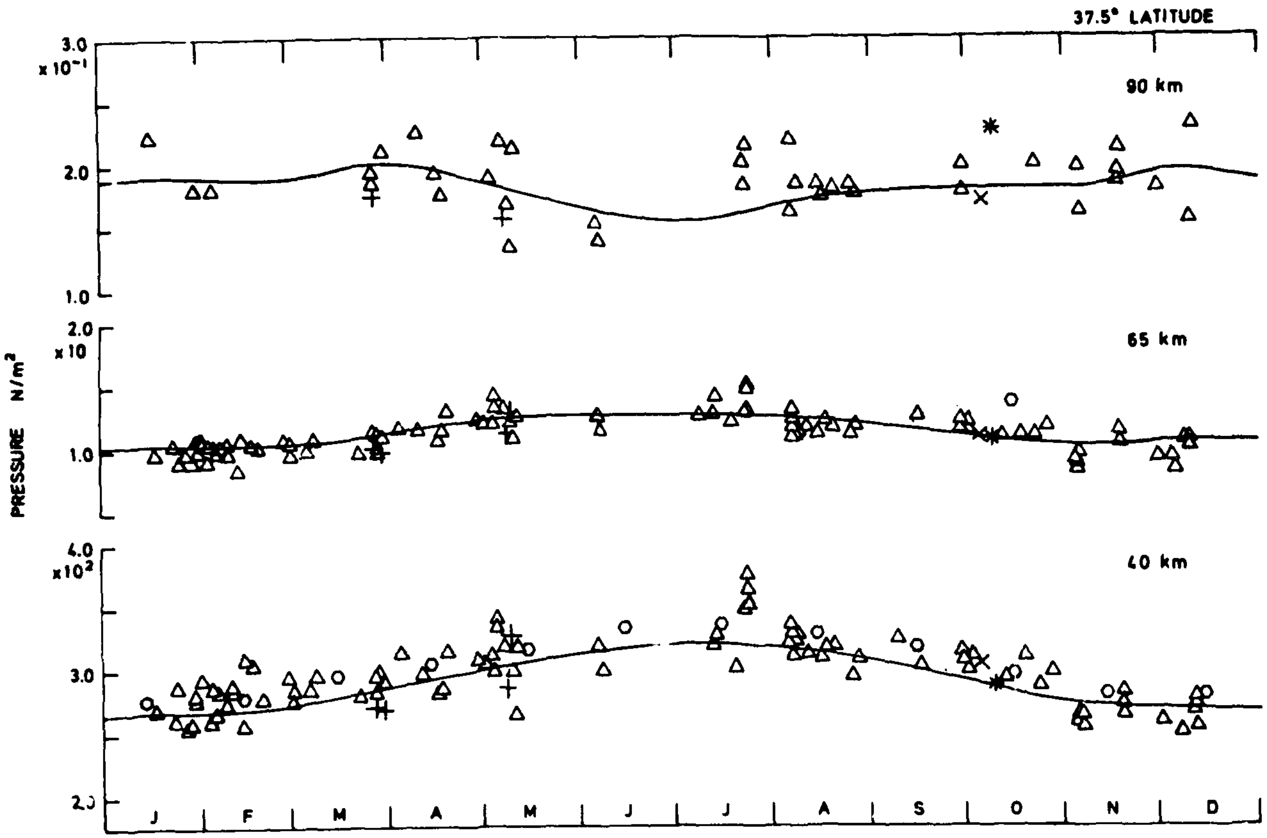
Figure 49. The Seasonal Variation of 30° Latitude Pressure and Density. Data points are compared with 30°N curves from Tables 24b and 26b. S. Hemisphere data are shifted 6 months in date



Key:

X Carnarvon (25°S) [110, 191, 192]; + Woomera (31°S) [43, 44, 45, 46, 47, 191, 193, 194, 195, 196, 197, 198]; O Eglin (30°N) [49, 50, 51, 190]; □ White Sands (32°N) [52, 53, 190]; ◁ White Sands MRN monthly mean values [15]; ▷ Cape Kennedy (28°N) MRN monthly mean values [15]; △ Holloman (33°N) [190]; ▽ Point Mugu (34°N) [190]

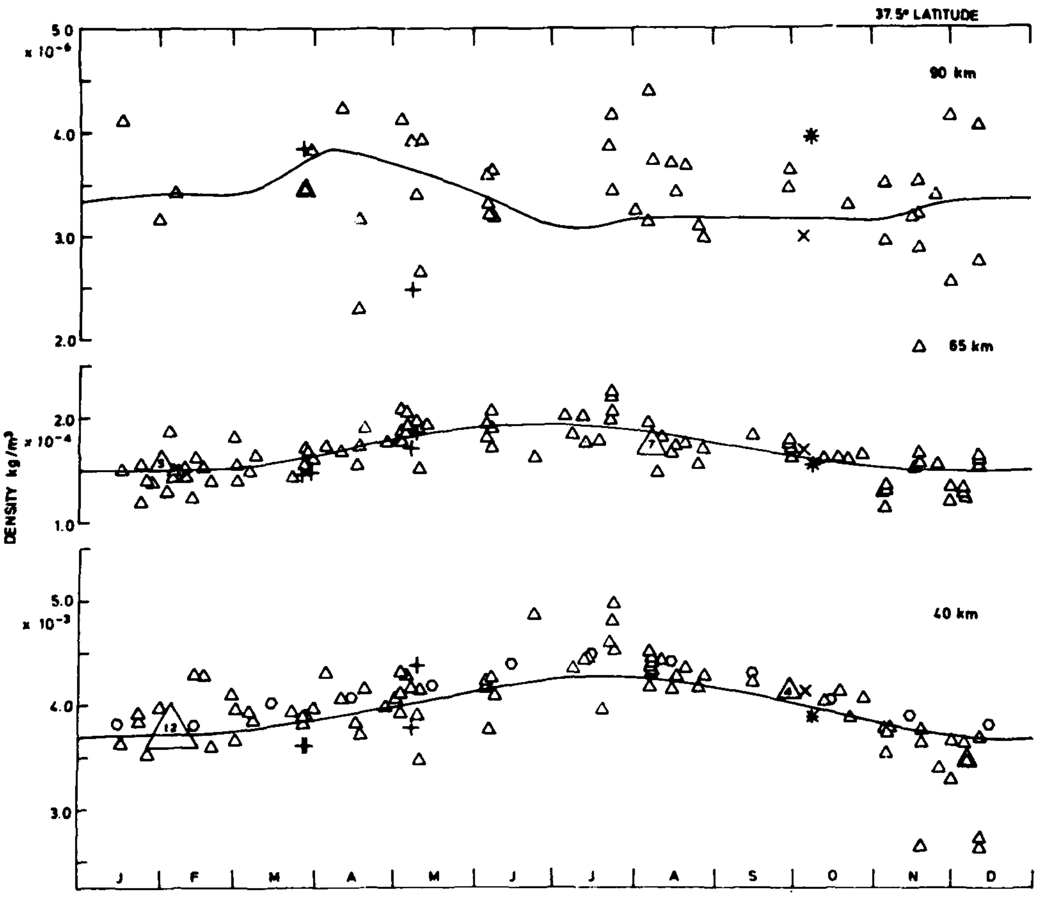
Figure 49 (Contd.). The Seasonal Variation of 30° Latitude Pressure and Density. Data points are compared with 30°N curves from Tables 24b and 26b. S. Hemisphere data are shifted 6 months in date



Key:

△ Wallops Is. (38°N) [20, 22, 23, 24, 55, 56, 190, 199]; + Arenosillo (37°N) [199]; X Ship (35°S) [55]; ✱ Ship (44°S) [55]; ○ Wallops Is. MRN monthly mean values [15]

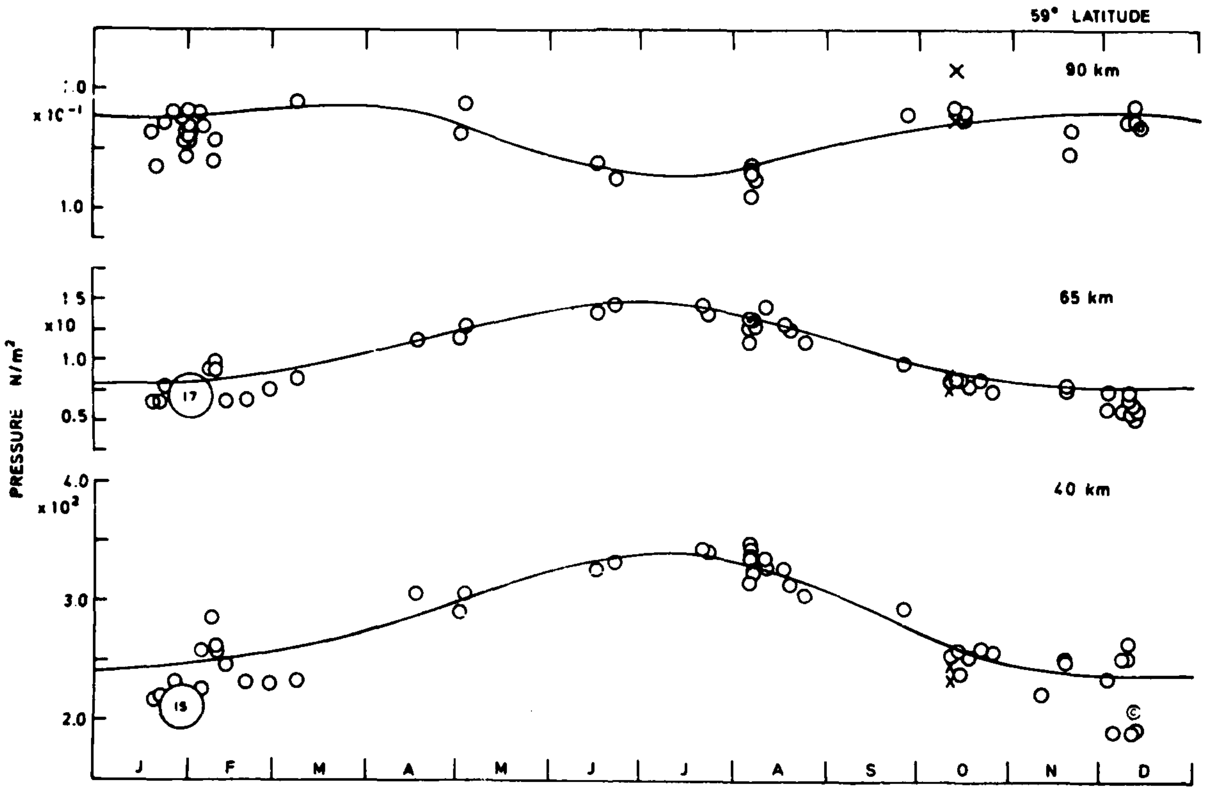
Figure 50. The Seasonal Variation of Pressure and Density at 37.5°N Latitude. Data points are compared with 37.5°N curves from Tables 24b and 26b. S. Hemisphere data are shifted 6 months in date



Key:

△ Wallops Is. (38°N) [20, 22, 23, 24, 55, 56, 190, 199]; + Arenosillo (37°N) [199]; X Ship (35°S) [55]; ✱ Ship (44°S) [55]; ○ Wallops Is. MRN monthly mean values [15]

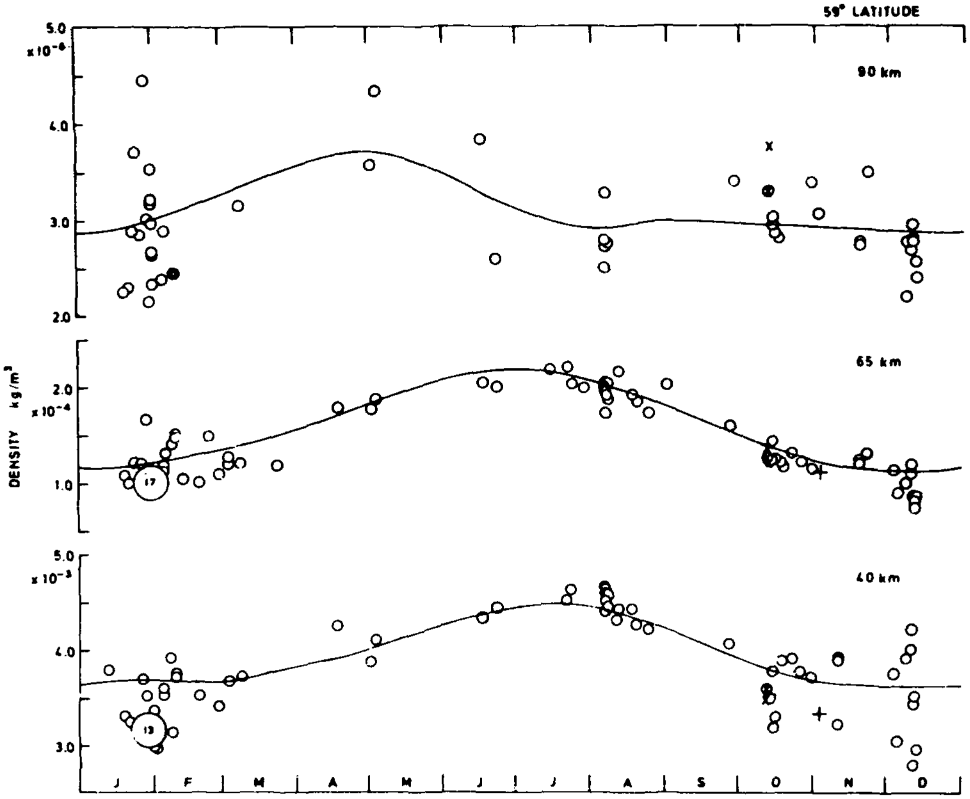
Figure 50 (Contd.). The Seasonal Variation of Pressure and Density at 37.5°N Latitude. Data points are compared with 37.5°N curves from Tables 24b and 26b. S. Hemisphere data are shifted 6 months in date



Key:

O Fort Churchill (59°N) [20, 21, 22, 23, 50, 55, 56, 190, 199]; X Ship (60°S) [55]; + Ship (58°N) [190]

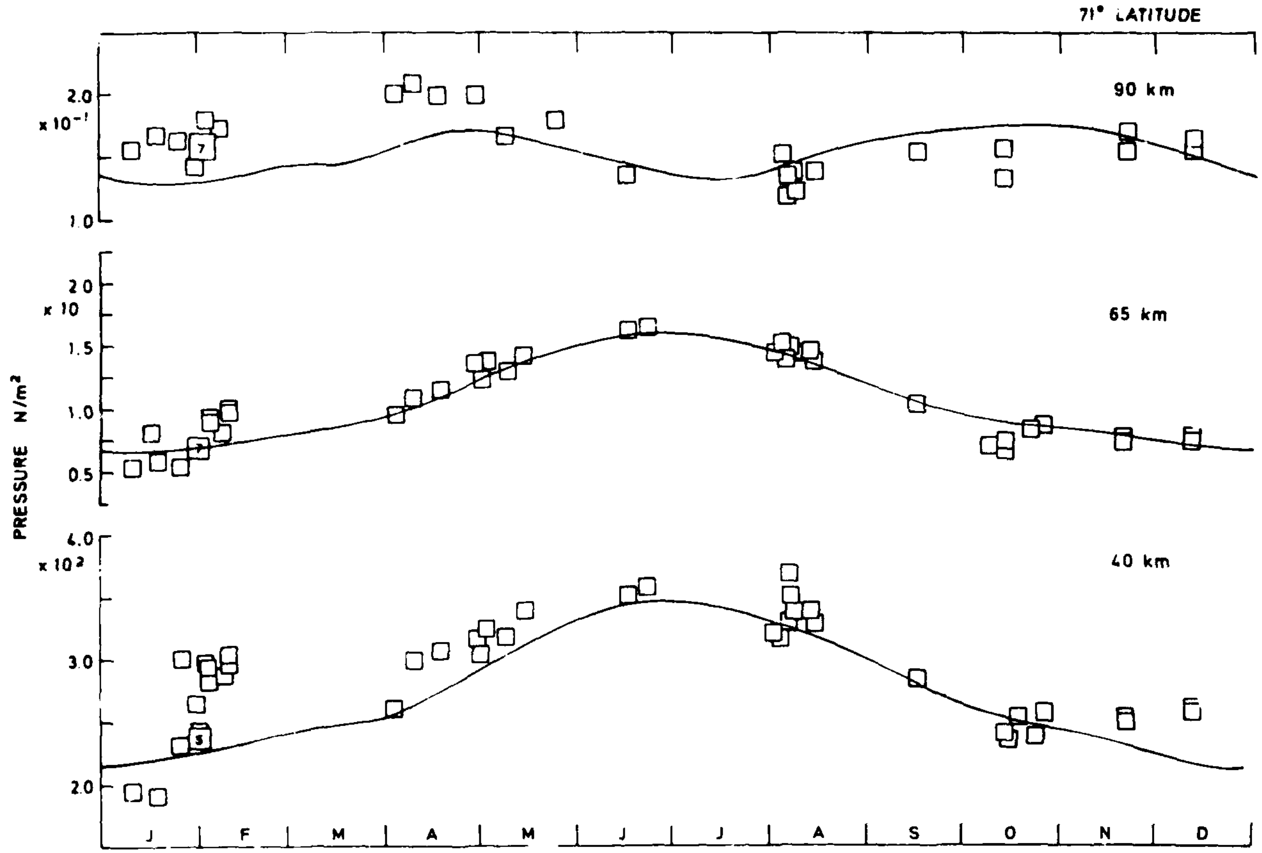
Figure 51. The Seasonal Variation of Pressure and Density at 59°N Latitude. Data points are compared with 59°N curves from Tables 24b and 26b. S. Hemisphere data are shifted 6 months in date



Key:

Fort Churchill (59°N) [20, 21, 22, 23, 50, 55, 56, 190, 199]; X Ship (60°S) [55]; + Ship (58°N) [190]

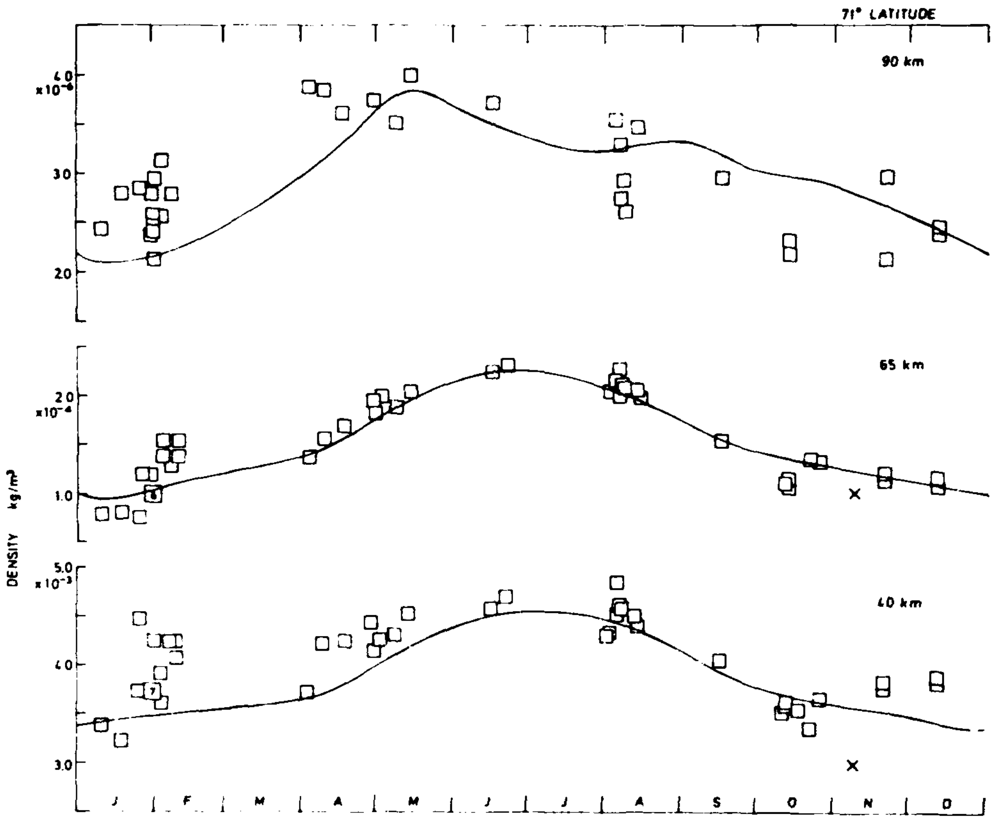
Figure 51 (Contd.). The Seasonal Variation of Pressure and Density at 59°N Latitude. Data points are compared with 59°N curves from Tables 24b and 26b. S. Hemisphere data are shifted 6 months in date



Key:

□ Point Barrow (71°N) [22, 23, 55, 56, 199]; X Ship (66°N) [190]

Figure 52. The Seasonal Variation of Pressure and Density at 71°N Latitude. Data points are compared with the 71°N curves from Tables 24b and 26b



Key:

□ Point Barrow (71°N) [22, 23, 55, 56, 199]; X Ship (66°N) [190]

Figure 52 (Contd.). The Seasonal Variation of Pressure and Density at 71°N Latitude. Data points are compared with the 71°N curves from Tables 24b and 26b

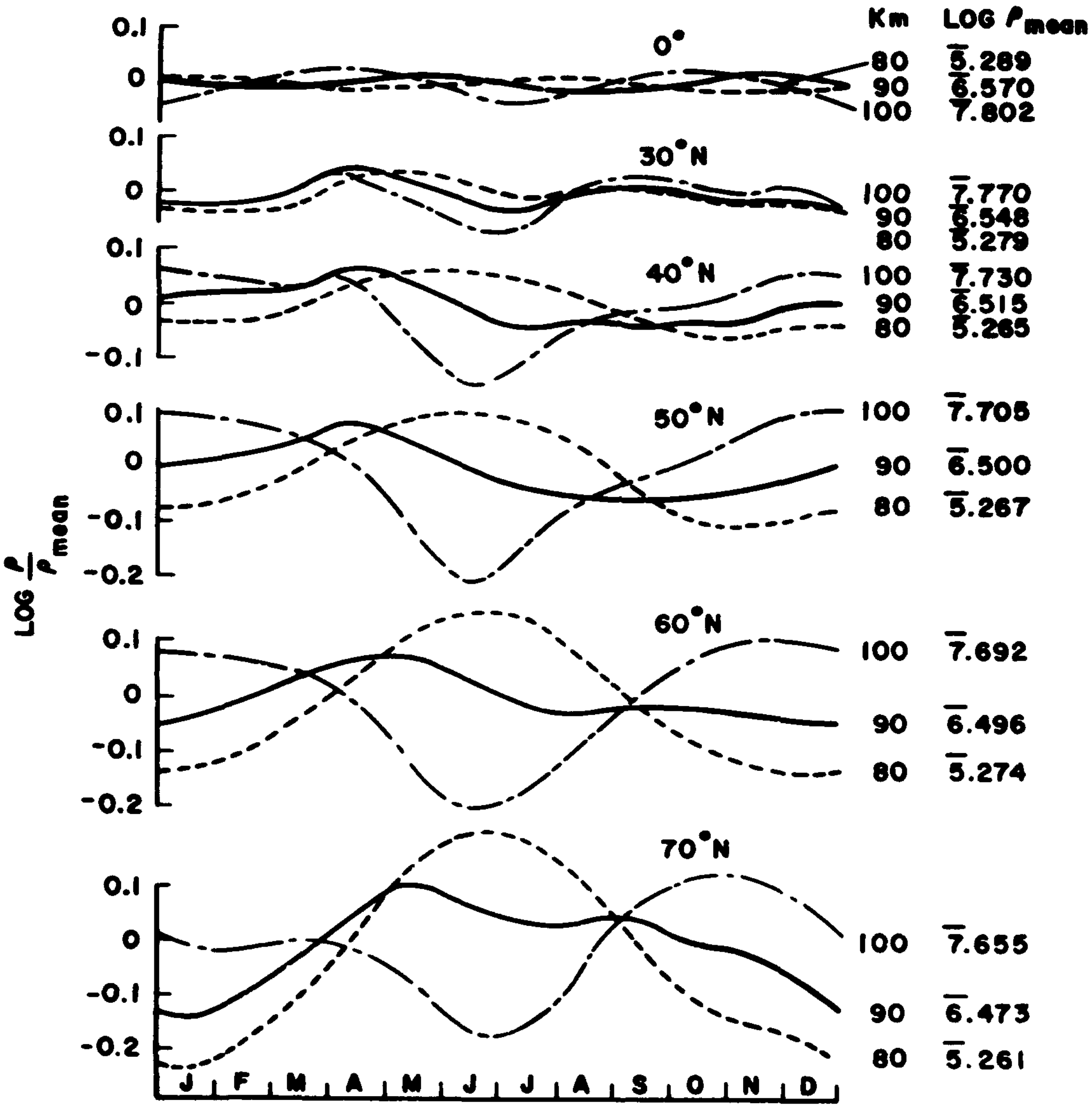


Figure 53. A Comparison of the 90 km Density Model With the 80 km and 100 km Models (Table 26b)

Table 1. N. Hemisphere Wind Data Analysed - 25 to 60 km

Station	Latitude	Longitude	No. of Profiles and Monthly Means	References (Square Brackets) Followed by No. of Launchings
Sites at 10 (±5) °N				
Thumba*	8° 32'N	76° 52'E	25	[15] 25
Kwajalein	8° 44'N	167° 44'E	37	[15] 37
Fort Sherman*	9° 20'N	79° 59'W	363	[15] 363
Eniwetok	11° 26'N	162° 23'E	19	[15] 19
Barbados*	13° 06'N	59° 37'W	18	[15] 18
Guam	13° 30'N	145° 00'E	9	[16] 9
Sites at 20 (±5) °N				
Antigua	17° 09'N	61° 47'W	159	[15] 159
Johnston Is. *	18° 00'N	170° 00'W	5	[9] 4, [17] 1
Grand Turk*	21° 26'N	71° 09'W	239	[15] 239
Barking Sands	21° 54'N	159° 35'W	443	[15] 430, [17] 8, [18] 5
San Salvador*	24° 04'N	74° 31'W	14	[15] 14
Sites at 30 (±5) °N				
N. America				
Eleuthera*	25° 16'N	76° 19'W	1	[15] 1
Cape Kennedy	28° 27'N	80° 32'W	847 48+	[15] 847 [15] 48
Eglin	30° 23'N	86° 42'W	98	[15] 98
Kindley	32° 21'N	64° 39'W	16	[15] 16
White Sands	32° 23'N	106° 29'W	1052 48+	[15] 1052 [15] 48
Holloman	32° 51'N	106° 06'W	48	[15] 48
San Nicolas*	33° 14'N	119° 25'W	1	[15] 1
Point Mugu	34° 07'N	119° 07'W	700 48+	[15] 700 [15] 48
Europe/W. Asia				
Sonmiani*	25° 11'N	66° 44'E	32	[19] 32
Others				
Uchinoura*	31° 15'N	131° 05'E	19	[15] 19

Notes· New sites since the CIRA 1965 analysis
+ Monthly means

Table 1. N. Hemisphere Wind Data Analysed - 25 to 60 km (Cont'd.)

Station	Latitude	Longitude	No. of Profiles and Monthly Means	References (Square Brackets) Followed by No. of Launchings
Sites at 40 (±5) °N				
Wallops Is.	37° 50'N	75° 29'W	488	[15] 439, [20] 23, [21] 16, [22] 9, [23] 1
			48+	[15] 48
Tonopah	38° 00'N	116° 30'W	90	[15] 72, [24] 16, [17] 2
Green River*	38° 56'N	110° 04'W	44	[15] 44
Europe/W. Asia				
Arenosillo*	37° 06'N	6° 44'W	30	[15] 30
Sardinia*	40° 00'N	10° 00'E	90	[25] 48, [26] 33, [27] 9
Others				
Akita	39° 34'N	140° 04'E	6	[28] 6
Sites at 50 (±5) °N				
N. America				
Primrose Lake*	54° 45'N	110° 03'W	83	[15] 83
Europe/W. Asia				
Volgograd*	48° 41'N	44° 21'E	67	[29] 12, [30] 55
Aberporth*	52° 08'N	4° 34'W	4	[31] 4
Sites at 60 (±5) °N				
N. America				
Fort Churchill	58° 44'N	93° 49'W	200	[15] 174, [32] 9, [20] 5, [21] 7, [23] 5
Fort Greely	64° 00'N	145° 44'W	343	[15] 343
			48+	[15] 48
Europe/W. Asia				
W. Geirinish*	57° 21'N	7° 22'W	116	[15] 116
Sites at 70 (±5) °N				
N. America				
Point Barrow	71° 21'N	156° 59'W	20	[15] 8, [22] 12

Notes: * New sites since the CIRA 1965 analysis
+ Monthly means

Table 1. N. Hemisphere Wind Data Analysed - 25 to 60 km (Cont'd.)

Station	Latitude	Longitude	No. of Profiles and Monthly Means	References (Square Brackets) Followed by No. of Launchings
Europe/W. Asia				
Kiruna*	67^{o} 53'N	21^{o} 06'E	12	[33] 12
Sites at 80 (±5) ^{o}N				
N. America				
Thule*	76^{o} 33'N	68^{o} 49'W	260	[15] 260
Europe/W. Asia				
Heiss Is.*	80^{o} 37'N	58^{o} 03'E	21	[15] 21

Notes: * New sites since the CIRA 1965 analysis

Table 2. S. Hemisphere Wind Data Analysed - 25 to 60 km

Station	Latitude	Longitude	No. of Profiles and Monthly Means	References (Square Brackets) Followed by No. of Launchings
Sites at 0 to 5 °S				
Gan*	0° 41'S	73° 09'E	28	[34] 28
Sites at 10 (±5) °S				
Natal*	5° 55'S	35° 10'W	60	[35] 16, [36] 16, [37] 12, [22] 12, [23] 3, [15] 1
Ascension Is.	7° 59'S	14° 25'W	347 24+	[15] 343, [21] 4 [15] 24
Sites at 20 (±5) °S				
Tartagal*	22° 46'S	63° 49'W	11	[15] 11
Sites at 30 (±5) °S				
Carnarvon*	25° 00'S	114° 00'E	12	[38] 12
Chamical*	30° 22'S	66° 17'W	32	[35] 14, [36] 10, [37] 8
Woomera	30° 57'S	136° 31'E	89	[38] 52, [39] 4, [40] 6, [41] 7, [42] 4, [43] 1, [44] 5, [45] 2, [46] 4, [47] 4
Sites at 40 (±5) °S				
Mar Chiquita*	37° 45'S	57° 25'W	17	[37] 15, [15] 2
Sites at 80 (±5) °S				
McMurdo Sound	77° 53'S	166° 44'E	28	[15] 28
Ship-board Launchings				
USSR research vessels A. I. Voeykov and Yu. M. Shokalsky*	Various latitudes and longitudes		4 seasonal means based on 200 launchings	[48] 4

Notes: * New sites since the CIRA 1965 analysis
+ Monthly means

Table 3. Temperature Data Analysed - 20 to 60 km

Station	Latitude	Longitude	No. of Profiles and Monthly Means	References (Square Brackets) Followed by No. of Launchings
Sites between 70 and 160 °W				
Fort Sherman	9° 20'N	79° 59'W	176	[15] 176
Grand Turk	21° 26'N	71° 09'W	169	[15] 169
Barking Sands	21° 54'N	159° 35'W	54	[15] 50, [18] 4
San Salvador	24° 04'N	74° 31'W	9	[15] 9
Cape Kennedy	28° 27'N	80° 32'W	156 48+	*[15] 156 [15] 48
Eglin	30° 23'N	86° 42'W	7	[49] 4, [50] 1, [51] 2
White Sands	32° 23'N	106° 29'W	77 48+	*[15] 65, [52] 4, [53] 4, [54] 4 [15] 48
San Nicolas	33° 14'N	119° 25'W	1	*[15] 1
Point Mugu	34° 07'N	119° 07'W	63 48+	*[15] 63 [15] 48
Wallops Is.	37° 50'N	75° 29'W	137 48+	[15] 74, [20] 23, [21] 16, [55] 11, [56] 13 [15] 48
Primrose Lake	54° 45'N	110° 03'W	1	[15] 1
Fort Churchill	58° 44'N	93° 49'W	259	[15] 207, [20] 5, [21] 16, [50] 3, [55] 11, [56] 11, [57] 2, [58] 4
Fort Greely	64° 00'N	145° 44'W	285 48+	[15] 285 [15] 48
Point Barrow	71° 21'N	156° 59'W	26	[15] 6, [55] 11, [56] 9
USNS Croatan	Various latitudes and longitudes		8	[55] 8
Sites not between 70 and 160°W				
Natal	5° 55'S	35° 10'W	31	[22] 12, [35] 9, [37] 1, [56] 9
Ascension Is.	7° 59'S	14° 25'W	264 24+	*[15] 254, [21] 7, [55] 2, [56] 1 [15] 24

Notes: * Only data between July 1964 and June 1966 were analysed
+ Monthly means

Table 3. Temperature Data Analysed - 20 to 60 km (Cont'd.)

Station	Latitude	Longitude	No. of Profiles and Monthly Means	References (Square Brackets) Followed by No. of Launchings
Kwajalein	8° 44'N	167° 44'E	20	*[15] 1, [59] 13, [60] 6
Guam	13° 30'N	145° 00'E	6	[21] 6
Antigua	17° 09'N	61° 47'W	149	*[15] 149
Carnarvon	25° 00'S	114° 00'E	11	[38] 11
Sonmiani	25° 11'N	66° 44'E	2	[61] 2
Chamical	30° 22'S	66° 17'W	8	[35] 6, [37] 2
Woomera	30° 57'S	136° 31'E	57	[38] 30, [39] 2, [40] 7, [41] 7, [42] 4, [43] 1, [44] 5, [62] 1
Hammaguir	31° 00'N	3° 00'W	4	[63] 1, [64] 3
Uchinoura	31° 15'N	131° 05'E	10	*[15] 10
Kindley	32° 21'N	64° 39'W	4	*[15] 4
Akita	39° 34'N	140° 04'E	6	[28] 6
Sardinia	40° 00'N	10° 00'E	11	[25] 6, [27] 3, [65] 2
Volgograd	48° 41'N	44° 21'E	21	[29] 12, [66] 9
West Geirinish	57° 21'N	7° 22'W	99	[15] 99
Thule	76° 33'N	68° 49'W	219	[15] 219
Heiss Is.	80° 37'N	58° 03'E	36	*[15] 21, [66] 12, [67] 3

Notes: * Only data between July 1964 and June 1966 were analysed

Table 4. Wind Data From Rocket and Gun-Probe Techniques - 60 to 130 km

Station	Latitude	Longitude	No. of Profiles			References (Square Brackets) Followed by No. of Launchings
			Sensor	Grenades	Chemical Release	
10° latitude sites						
Natal	5° 55'S	35° 10'W	-	15	-	[22] 12, [23] 3
Ascension Is.	7° 59'S	14° 25'W	18	3	-	[15] 18, [21] 3
Thumba	8° 32'N	76° 52'E	-	-	6	[131] 6
Guam	13° 30'N	145° 00'E	-	4	-	[16] 4
Barbados	13° 04'N	59° 29'W	-	-	76	[15] 76
20° latitude sites						
Antigua	17° 09'N	61° 47'W	4	-	-	[15] 4
Johnston Is.	18° 00'N	170° 00'W	17	-	-	[9] 16, [17] 1
Vega Baja	18° 15'N	66° 30'W	-	-	3	[135] 3
Barking Sands	21° 54'N	159° 35'W	35	-	3	[15] 23, [17] 12, [18] 3
30° latitude sites						
Carnarvon	25° 00'S	114° 00'E	11	-	-	[38] 11
Sonmiani	25° 11'N	66° 44'E	3	-	2	[19] 3, [136] 2
Reggan	26° 42'N	0° 00'	-	-	5	[137] 5
Cape Kennedy	28° 27'N	80° 32'W	20	-	-	[15] 20
Chamical	30° 22'S	66° 17'W	-	-	10	[138] 2, [139] 5, [140] 3
Eglin	30° 23'N	86° 42'W	15	-	57	[15] 15, [135] 17, [141] 19, [142] 12, [143] 9
Woomera	30° 57'S	136° 31'E	46	22	21	[38] 36, [39] 4, [40] 2, [41] 5, [42] 4, [43] 1, [44] 5, [45] 2, [46] 4, [47] 4, [144] 2, [145] 4, [146] 4
Hammaguir	31° 00'N	3° 00'W	-	-	15	[137] 6, [147] 6, [148] 2, [149] 1
Uchinoura	31° 15'N	131° 05'E	-	-	2	[150] 2
White Sands	32° 23'N	106° 29'W	169	-	-	[15] 169
Holloman	32° 51'N	106° 06'W	4	-	3	[15] 4, [151] 3

Table 4. Wind Data From Rocket and Gun-Probe Techniques - 60 to 130 km (Cont'd.)

Station	Latitude	Longitude	No. of Profiles: Sensor	Grenades	Chemical Release	References (Square Brackets) Followed by No. of Launchings
Yuma	32° 52'N	114° 19'W	-	-	25	[15] 25
Point Mugu	34° 07'N	119° 07'W	59	-	-	[15] 59
40° latitude sites						
Arenosillo	37° 06'N	6° 44'W	1*	-	-	[152] 1
Wallops Is.	37° 50'N	75° 29'W	27	58	34	[15] 27, [20] 22, [21] 16, [22] 9, [55] 11, [138] 34
Tonopah	38° 00'N	116° 30'W	59	-	-	[15] 17, [9] 3, [17] 1, [24] 38
Green River	38° 56'N	110° 04'W	8	-	-	[15] 8
Akita	39° 34'N	140° 04'E	-	1	-	[28] 1
Sardinia	40° 00'N	10° 00'E	11	-	8	[25] 3, [26] 8, [138] 3, [153] 5
Ile du Levant	43° 00'N	6° 00'E	-	-	2	[138] 2
60° latitude sites						
Aberporth	52° 08'N	4° 34'W	1	-	-	[31] 1
Fort Churchill	58° 44'N	93° 49'W	3	32	5	[15] 3, [20] 5, [21] 7, [32] 9, [55] 11, [138] 5
Fort Greely	64° 00'N	145° 44'W	27	-	-	[15] 27
Kiruna	67° 53'N	21° 06'E	-	-	4	[154] 4
Point Barrow	71° 21'N	156° 59'W	-	22	-	[55] 10, [22] 12
McMurdo Sound	77° 53'S	166° 44'E	3	-	-	[15] 3

Note: *Mean value 24-28 February 1970

Table 5. Wind Data From Ground-Based Techniques - 65 to 110 km

Station	Latitude	Longitude	Altitude (km)	References
Adelaide	35°S	139°E	80-100	156, 157
Palo Alto	37°N	122°W	95	134
Kharkov	50°N	36°E	95	158, 159, 160
Saskatoon	52°N	106°W	65-110	161
Jodrell Bank	53°N	2°W	95	162
Sheffield	53°N	1°W	95	163
Kühlungsborn	54°N	12°E	95	164
Collm	51°N	13°E		
Obninsk	55°N	36°E	95	160, 165
Kazan	56°N	49°E	80-100	166
Mawson	68°S	62°E	80-100	167

Table 6. Temperature Data Analysed - 60 to 110 km

Station	Latitude	Longitude	No. of Profiles	References (Square Brackets) Followed by No. of Launchings
USNS Croatan	Various latitudes and longitudes		8	[55] 8
Natal	5^{o} 55'S	35^{o} 10'W	9	[56] 9
Ascension Is.	7^{o} 59'S	14^{o} 25'W	9	[21] 6, [55] 2, [56] 1
Kwajalein	8^{o} 44'N	167^{o} 44'E	17	[59] 11, [60] 6
Guam	13^{o} 30'N	145^{o} 00'E	5	[21] 5
Barking Sands	21^{o} 54'N	159^{o} 35'W	5	[18] 4, [168] 1
Carnarvon	25^{o} 00'S	114^{o} 00'E	11	[38] 11
Sonmiani	25^{o} 11'N	66^{o} 44'E	2	[61] 1, [169] 1
Eglin	30^{o} 23'N	86^{o} 42'W	12	[49] 4, [50] 1, [51] 2, [169] 2, [170] 3
Woomera	30^{o} 57'S	136^{o} 31'E	52	[38] 27, [39] 2, [40] 6, [41] 6, [42] 4, [43] 1, [44] 5, [62] 1
White Sands	32^{o} 23'N	106^{o} 29'W	13	[52] 4, [53] 4, [54] 5
Wallops Is.	37^{o} 50'N	75^{o} 29'W	66	[15] 3, [20] 23, [21] 16, [55] 11, [56] 13
Akita	39^{o} 34'N	140^{o} 04'E	2	[28] 2
Sardinia	40^{o} 00'N	10^{o} 00'E	2	[65] 1, [169] 1
St. Santin	44^{o} 42'N	2^{o} 12'E	29*	[171] 29
Volgograd	48^{o} 41'N	44^{o} 21'E	18	[29] 9, [66] 9
Fort Churchill	58^{o} 44'N	93^{o} 49'W	53	[20] 5, [21] 16, [50] 3, [55] 11, [56] 11, [57] 2, [58] 4, [172] 1
Point Barrow	71^{o} 21'N	156^{o} 59'W	19	[55] 11, [56] 8
Heiss Is.	80^{o} 37'N	58^{o} 03'E	27	[15] 12, [66] 12, [67] 3

Note: * From Thomson radar scatter

Table 7a. W-E Winds 25 to 60 km. Based on N. Hemisphere data from all longitudes except for sites north of 25°N where, between mid-September and mid-April, only data from N. America are included. Winds to the east are positive in m/s

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	80
JANUARY 1									
25	-17	-10	1	2	10	-22	35	21	25
30	-13	0	4	7	35	-17	26	46	10
35	-14	2	5	13	56	-6	23	58	-3
40	-20	-4	4	19	75	15	26	56	-15
45	-35	-16	-3	26	88	27	35	41	-25
50	-51	-17	-5	35	91	19	43	18	-30
55	-50	4	10	47	87	5	40	-2	-23
60	-24	26	35	61	90	14	27	-9	-5
FEBRUARY 1									
25	-14	-5	-1	-2	13	17	14	11	21
30	-28	-12	-3	-1	18	30	10	44	7
35	-36	-17	-5	6	26	47	8	63	0
40	-41	-21	-9	19	37	71	9	66	2
45	-36	-17	-7	34	51	97	10	58	10
50	-15	0	2	47	66	119	9	44	15
55	9	22	10	55	77	122	7	31	10
60	23	29	2	62	82	95	9	22	-1
MARCH 1									
25	-30	-8	-1	5	3	13	26	18	14
30	-36	-14	-3	12	13	17	20	12	8
35	-34	-15	-4	19	26	24	19	6	3
40	-20	-11	-6	26	42	35	24	-1	0
45	-3	3	-2	32	56	48	33	-10	-2
50	12	19	12	42	60	57	41	-19	-3
55	22	26	30	52	59	60	48	-20	-2
60	32	28	46	57	61	55	62	-7	2
APRIL 1									
25	-10	-13	-3	-1	13	7	16	-24	30
30	8	-19	-9	6	20	16	4	-1	26
35	20	-18	-10	12	26	25	-3	12	22
40	26	-10	-5	17	32	36	-6	14	18
45	28	5	5	22	36	51	-6	12	13
50	35	20	17	27	38	67	-8	9	8
55	44	34	30	30	37	72	-12	6	7
60	47	44	41	23	34	60	-13	1	7

Table 7a. W-E Winds 25 to 60 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70	80
MAY 1									
25	-7	-15	-8	-5	-1	-8	-2	-3	-6
30	1	-13	-11	2	5	-5	-8	-8	-19
35	9	-10	-12	5	8	-7	-11	-11	-26
40	17	-4	-10	3	7	-13	-10	-12	-25
45	28	1	-7	0	4	-22	-9	-12	-25
50	38	7	-1	-4	-1	-24	-9	-14	-31
55	43	11	3	-6	-7	-18	-11	-18	-32
60	38	9	2	-8	-11	-5	-11	-20	-21
JUNE 1									
25	-21	-22	-20	-8	-3	-7	-8	-10	-7
30	-14	-21	-18	-8	-3	-12	-11	-8	-7
35	-7	-18	-18	-11	-6	-15	-14	-7	-5
40	-2	-11	-21	-17	-10	-18	-15	-6	0
45	1	-10	-27	-24	-16	-20	-17	-10	2
50	2	-15	-32	-31	-22	-24	-20	-20	-4
55	5	-14	-33	-39	-25	-26	-24	-32	-14
60	11	-7	-32	-47	-25	-23	-31	-38	-16
JULY 1									
25	-24	-24	-21	-15	-9	-13	-8	-9	-5
30	-18	-26	-26	-17	-14	-15	-11	-11	-3
35	-15	-28	-31	-21	-21	-19	-15	-14	-4
40	-16	-30	-37	-28	-29	-21	-18	-19	-8
45	-18	-30	-41	-37	-36	-27	-23	-22	-13
50	-17	-26	-42	-46	-44	-47	-27	-25	-16
55	-9	-19	-34	-52	-51	-54	-34	-28	-19
60	5	-10	-13	-55	-59	-64	-45	-36	-23
AUGUST 1									
25	-22	-25	-27	-18	-11	-4	-6	-3	-3
30	-23	-29	-27	-22	-13	-8	-7	-4	-4
35	-23	-29	-30	-27	-17	-13	-8	-5	-5
40	-22	-26	-35	-34	-23	-19	-11	-7	-5
45	-19	-18	-39	-41	-30	-24	-15	-11	-7
50	-14	-11	-38	-46	-38	-24	-23	-16	-11
55	-8	-12	-33	-46	-50	-21	-33	-19	-14
60	-1	-11	-30	-38	-63	-27	-43	-23	-16

Table 7a. W-E Winds 25 to 60 km (Contd.)

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	80
SEPTEMBER 1									
25	-1	-23	-19	-14	-5	0	-1	-4	-4
30	-25	-21	-23	-14	-11	0	-4	-3	2
35	-35	-20	-23	-16	-16	-1	-5	-2	4
40	-28	-20	-21	-19	-20	-2	-4	1	4
45	-12	-19	-16	-23	-22	-6	-2	4	1
50	3	-17	-7	-23	-22	-13	2	8	0
55	14	-12	7	-17	-20	-21	4	11	3
60	24	-1	23	-8	-16	-24	3	9	6
OCTOBER 1									
25	-9	-19	-17	-4	3	-6	21	11	5
30	-13	-18	-13	-5	7	1	32	16	-2
35	-12	-13	-7	-3	11	10	39	21	0
40	-8	-2	2	2	16	20	43	26	13
45	4	8	10	9	20	31	44	29	27
50	22	11	14	16	19	43	44	28	29
55	35	13	12	21	17	50	37	21	26
60	40	17	5	23	19	43	19	7	18
NOVEMBER 1									
25	17	-13	-12	0	10	3	11	10	22
30	16	-7	-1	9	21	7	10	13	25
35	17	2	9	19	32	14	13	13	25
40	17	14	20	29	44	23	21	11	20
45	23	25	27	39	58	33	31	8	16
50	32	30	34	49	74	45	36	6	17
55	39	32	45	58	63	56	29	6	24
60	39	34	52	62	60	63	16	7	27
DECEMBER 1									
25	-20	-19	-10	8	13	14	13	10	5
30	-10	-9	-2	25	26	28	8	15	2
35	-4	0	8	41	41	36	7	17	1
40	-2	11	22	56	57	34	10	17	2
45	-7	14	32	67	71	38	14	13	4
50	-16	6	39	70	81	54	21	8	4
55	-10	4	49	64	67	71	24	4	5
60	-9	11	53	54	83	71	22	2	3

Table 7b. W-E Winds 25 to 60 km. Based on N. Hemisphere data from all longitudes except for sites north of 25^{o}N where, between mid-September and mid-April, only data from N. America are included. Winds to the east are positive in m/s. Values apply to the first day of each month

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES N												
25	-17	-14	-30	-10	-7	-21	-24	-22	-1	-9	17	-20
30	-13	-20	-36	8	1	-14	-18	-23	-25	-13	16	-10
35	-14	-36	-34	20	9	-7	-15	-23	-35	-12	17	-4
40	-20	-41	-20	26	17	-2	-16	-22	-28	-8	17	-2
45	-35	-36	-3	28	28	1	-18	-19	-12	4	23	-7
50	-51	-15	12	35	38	2	-17	-14	3	22	32	-16
55	-50	9	22	44	43	5	-9	-8	14	35	39	-13
60	-24	23	32	47	38	11	5	-1	24	40	39	-9
10 DEGREES N												
25	-10	-5	-8	-13	-15	-22	-24	-25	-23	-19	-13	-19
30	0	-12	-14	-19	-13	-21	-26	-29	-21	-18	-7	-9
35	2	-17	-15	-18	-10	-18	-28	-29	-20	-13	2	0
40	-4	-21	-11	-10	-4	-11	-30	-26	-20	-2	14	11
45	-16	-17	3	5	1	-10	-30	-18	-19	8	25	14
50	-17	0	19	20	7	-15	-26	-11	-17	11	30	6
55	4	22	26	34	11	-14	-19	-12	-12	13	32	4
60	26	29	28	44	9	-7	-10	-11	-1	17	34	11
20 DEGREES N												
25	1	-1	-1	-3	-8	-20	-21	-27	-19	-17	-12	-10
30	4	-3	-3	-9	-11	-18	-26	-27	-23	-13	-1	-2
35	5	-5	-4	-10	-12	-18	-31	-30	-23	-7	9	8
40	4	-9	-6	-5	-10	-21	-37	-35	-21	2	20	22
45	-3	-7	-2	5	-7	-27	-41	-39	-16	10	27	32
50	-5	2	12	17	-1	-32	-42	-38	-7	14	34	39
55	10	10	30	30	3	-33	-34	-33	7	12	45	49
60	35	2	46	41	2	-32	-13	-30	23	5	52	53
30 DEGREES N												
25	2	-2	5	-1	-5	-8	-15	-18	-14	-4	0	8
30	7	-1	12	6	2	-8	-17	-22	-14	-5	9	25
35	13	6	19	12	5	-11	-21	-27	-16	-3	19	41
40	19	19	26	17	3	-17	-28	-34	-19	2	29	56
45	26	34	32	22	0	-24	-37	-41	-23	9	39	67
50	35	47	42	27	-4	-31	-46	-46	-23	16	49	70
55	47	55	52	30	-6	-39	-52	-46	-17	21	58	64
60	61	62	57	23	-8	-47	-55	-38	-8	23	62	54

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 7b. W-E Winds 25 to 60 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40 DEGREES N												
25	10	13	3	13	-1	-3	-9	-11	-5	3	10	13
30	35	18	13	20	5	-3	-14	-13	-11	7	21	26
35	56	26	26	26	8	-6	-21	-17	-16	11	32	41
40	75	37	42	32	7	-10	-29	-23	-20	16	44	57
45	68	51	56	36	4	-16	-36	-30	-22	20	58	71
50	91	66	60	38	-1	-22	-44	-38	-22	19	74	81
55	87	77	59	37	-7	-25	-51	-50	-20	17	83	87
60	90	82	61	34	-11	-25	-59	-63	-16	19	80	83
50 DEGREES N												
25	-22	17	13	7	-8	-7	-10	-4	0	-6	3	14
30	-17	30	17	16	-5	-12	-15	-8	0	1	7	28
35	-6	47	24	25	-7	-15	-19	-13	-1	10	14	36
40	15	71	35	36	-13	-18	-21	-19	-2	20	23	34
45	27	97	48	51	-22	-20	-27	-24	-6	31	33	38
50	19	119	57	67	-24	-24	-40	-24	-13	43	45	54
55	5	122	60	72	-18	-26	-54	-21	-21	50	56	71
60	14	95	55	60	-5	-23	-64	-27	-24	43	63	71
60 DEGREES N												
25	35	14	26	16	-2	-8	-8	-6	-1	21	11	13
30	26	10	20	4	-8	-11	-11	-7	-4	32	10	8
35	23	8	19	-3	-11	-14	-15	-8	-5	39	13	7
40	26	9	24	-6	-10	-15	-18	-11	-4	43	21	10
45	35	10	33	-6	-9	-17	-23	-15	-2	44	31	14
50	43	9	41	-8	-9	-20	-27	-23	2	44	36	21
55	40	7	48	-12	-11	-24	-34	-33	4	37	29	24
60	27	9	62	-13	-11	-31	-46	-43	3	19	16	22
70 DEGREES N												
25	21	11	18	-24	-3	-10	-9	-3	-4	11	10	10
30	46	44	12	-1	-8	-8	-11	-4	-3	16	13	15
35	58	63	6	12	-11	-7	-14	-5	-2	21	13	17
40	56	66	-1	14	-12	-6	-19	-7	1	26	11	17
45	41	58	-10	12	-12	-10	-22	-11	4	29	8	13
50	18	44	-19	9	-14	-20	-25	-16	8	28	6	8
55	-2	31	-20	6	-18	-32	-28	-19	11	21	6	4
60	-9	22	-7	1	-20	-38	-36	-23	9	7	7	2
80 DEGREES N												
25	25	21	14	30	-6	-7	-5	-3	-4	5	22	5
30	10	7	8	26	-19	-7	-3	-4	2	-2	25	2
35	-3	0	3	22	-26	-5	-4	-5	4	0	25	1
40	-15	2	0	18	-25	0	-8	-5	4	13	20	2
45	-25	10	-2	13	-25	2	-13	-7	1	27	16	4
50	-30	15	-3	8	-31	-4	-16	-11	0	29	17	4
55	-23	10	-2	7	-32	-14	-19	-14	3	26	24	5
60	-5	-1	2	7	-21	-16	-20	-16	6	18	27	3

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 8a. W-E Winds 25 to 60 km. Based on N. Hemisphere data from all longitudes except for sites north of 25°N where, between mid-September and mid-April, only data from Europe/W. Asia are included. Winds to the east are positive in m/s

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	80
JANUARY 1									
25	-17	-10	1	6	26	24	49	-1	15
30	-13	0	4	5	56	44	63	14	1
35	-14	2	5	4	77	62	70	27	-8
40	-20	-4	4	3	88	80	68	39	-11
45	-35	-16	-3	4	90	88	68	45	-11
50	-51	-17	-5	9	83	79	73	41	-9
55	-50	4	10	21	77	64	71	30	-3
60	-24	26	35	42	82	60	56	20	7
FEBRUARY 1									
25	-14	-5	-1	10	19	29	17	-21	8
30	-28	-12	-3	-3	35	41	21	-18	-7
35	-36	-17	-5	-8	47	52	28	-6	-11
40	-41	-21	-9	-5	54	61	36	17	-2
45	-36	-17	-7	6	63	71	47	42	14
50	-15	0	2	24	77	84	57	66	28
55	9	22	10	44	89	94	64	83	33
60	23	29	2	62	89	87	63	79	25
MARCH 1									
25	-30	-8	-1	7	13	12	14	8	4
30	-36	-14	-3	17	42	26	9	4	0
35	-34	-15	-4	25	63	37	8	-4	-5
40	-20	-11	-6	31	76	47	13	-14	-13
45	-3	3	-2	38	81	53	17	-28	-22
50	12	19	12	50	78	55	19	-42	-26
55	22	26	30	63	70	54	25	-42	-21
60	32	28	46	70	58	47	46	-22	-10
APRIL 1									
25	-10	-13	-3	-4	14	18	10	-25	29
30	8	-19	-9	6	24	19	13	7	37
35	20	-18	-10	13	31	24	14	27	40
40	26	-10	-5	18	34	31	14	34	39
45	28	5	5	22	34	45	11	33	34
50	35	20	17	30	35	66	6	28	27
55	44	34	30	37	37	76	0	22	21
60	47	44	41	35	35	65	-2	12	14

Table 8a. W-E Winds 25 to 60 km (Contd.)

KM	0	10	20	30	40	50	60	70	80
				LATITUDE (DEGREES N)					
MAY 1									
25	-7	-15	-8	-5	-1	-8	-2	-3	-6
30	1	-13	-11	2	5	-5	-8	-8	-19
35	9	-10	-12	5	8	-7	-11	-11	-26
40	17	-4	-10	3	7	-13	-10	-12	-25
45	28	1	-7	0	4	-22	-9	-12	-25
50	38	7	-1	-4	-1	-24	-9	-14	-31
55	43	11	3	-6	-7	-18	-11	-18	-32
60	38	9	2	-8	-11	-5	-11	-20	-21
JUNE 1									
25	-21	-22	-20	-8	-3	-7	-8	-10	-7
30	-14	-21	-18	-8	-3	-12	-11	-8	-7
35	-7	-18	-18	-11	-6	-15	-14	-7	-5
40	-2	-11	-21	-17	-10	-18	-15	-6	0
45	1	-10	-27	-24	-16	-20	-17	-10	2
50	2	-15	-32	-31	-22	-24	-20	-20	-4
55	5	-14	-33	-39	-25	-26	-24	-32	-14
60	11	-7	-32	-47	-25	-23	-31	-38	-16
JULY 1									
25	-24	-24	-21	-15	-9	-10	-8	-9	-5
30	-18	-26	-26	-17	-14	-15	-11	-11	-3
35	-15	-28	-31	-21	-21	-19	-15	-14	-4
40	-16	-30	-37	-28	-29	-21	-18	-19	-8
45	-18	-30	-41	-37	-36	-27	-23	-22	-13
50	-17	-26	-42	-46	-44	-40	-27	-25	-16
55	-9	-19	-34	-52	-51	-54	-34	-28	-19
60	5	-10	-13	-55	-59	-64	-46	-36	-20
AUGUST 1									
25	-22	-25	-27	-18	-11	-4	-6	-3	-3
30	-23	-29	-27	-22	-13	-8	-7	-4	-4
35	-23	-29	-30	-27	-17	-13	-8	-5	-5
40	-22	-26	-35	-34	-23	-19	-11	-7	-5
45	-19	-18	-39	-41	-30	-24	-15	-11	-7
50	-14	-11	-38	-46	-38	-24	-23	-16	-11
55	-8	-12	-33	-46	-50	-21	-33	-19	-14
60	-1	-11	-30	-38	-63	-27	-43	-23	-16

Table 8a. W-E Winds 25 to 60 km (Contd.)

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	80
SEPTEMBER 1									
25	-1	-23	-19	-14	-5	0	-1	-4	-4
30	-25	-21	-23	-14	-11	0	-4	-3	2
35	-35	-20	-23	-16	-16	-1	-5	-2	4
40	-28	-20	-21	-19	-20	-2	-4	1	4
45	-12	-19	-16	-23	-22	-6	-2	4	1
50	3	-17	-7	-23	-22	-13	2	8	0
55	14	-12	7	-17	-20	-21	4	11	3
60	24	-1	23	-8	-16	-24	3	9	6
OCTOBER 1									
25	-9	-19	-17	-6	2	2	10	2	-1
30	-13	-18	-13	-11	8	13	18	7	-7
35	-12	-13	-7	-12	12	19	26	14	-4
40	-8	-2	2	-9	16	21	34	22	13
45	4	8	10	-2	17	23	40	26	25
50	22	11	14	6	16	30	42	24	23
55	35	13	12	10	17	35	38	18	16
60	40	17	5	12	21	31	30	9	11
NOVEMBER 1									
25	17	-13	-12	1	12	12	21	2	-5
30	16	-7	-1	2	33	23	23	9	2
35	17	2	9	6	48	34	30	10	1
40	17	14	20	14	57	44	41	5	-12
45	23	25	27	24	63	56	54	-2	-28
50	32	30	34	31	65	66	61	-5	-32
55	39	32	45	36	67	68	55	-2	-18
60	39	34	52	46	69	64	41	4	-2
DECEMBER 1									
25	-20	-19	-10	10	18	33	15	-8	-30
30	-10	-9	-2	2	34	55	32	12	-27
35	-4	0	8	2	47	73	50	26	-26
40	-2	11	22	9	58	85	72	33	-27
45	-7	14	32	22	69	101	86	31	-29
50	-16	6	39	35	79	119	85	23	-30
55	-18	4	49	46	65	121	74	13	-25
60	-9	11	53	53	83	89	56	9	-18

Table 8b. W-E Winds 25 to 60 km. Based on N. Hemisphere data from all longitudes except for sites north of 25°N where, between mid-September and mid-April, only data from Europe/W. Asia are included. Winds to the east are positive in m/s. Values apply to the first day of each month

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES N												
25	-17	-14	-30	-10	-7	-21	-24	-22	-1	-9	17	-20
30	-13	-28	-36	8	1	-14	-18	-23	-25	-13	16	-10
35	-14	-36	-34	20	9	-7	-15	-23	-35	-12	17	-4
40	-20	-41	-20	26	17	-2	-16	-22	-28	-8	17	-2
45	-35	-36	-3	28	28	1	-18	-19	-12	4	23	-7
50	-51	-15	12	35	38	2	-17	-14	3	22	32	-16
55	-50	9	22	44	43	5	-9	-8	14	35	39	-18
60	-24	23	32	47	38	11	5	-1	24	40	39	-9
10 DEGREES N												
25	-10	-5	-8	-13	-15	-22	-24	-25	-23	-19	-13	-19
30	0	-12	-14	-19	-13	-21	-26	-29	-21	-18	-7	-9
35	2	-17	-15	-18	-10	-18	-28	-29	-20	-13	2	0
40	-4	-21	-11	-10	-4	-11	-30	-26	-20	-2	14	11
45	-16	-17	3	5	1	-10	-30	-18	-19	8	25	14
50	-17	0	19	20	7	-15	-26	-11	-17	11	30	6
55	4	22	26	34	11	-14	-19	-12	-12	13	32	4
60	26	29	28	44	9	-7	-10	-11	-1	17	34	11
20 DEGREES N												
25	1	-1	-1	-3	-8	-20	-21	-27	-19	-17	-12	-10
30	4	-3	-3	-9	-11	-18	-26	-27	-23	-13	-1	-2
35	5	-5	-4	-10	-12	-18	-31	-30	-23	-7	9	8
40	4	-9	-6	-5	-10	-21	-37	-35	-21	2	20	22
45	-3	-7	-2	5	-7	-27	-41	-39	-16	10	27	32
50	-5	2	12	17	-1	-32	-42	-38	-7	14	34	39
55	10	10	30	30	3	-33	-34	-33	7	12	45	49
60	35	2	46	41	2	-32	-13	-30	23	5	52	53
30 DEGREES N												
25	6	10	7	-4	-5	-8	-15	-18	-14	-6	1	10
30	5	-3	17	6	2	-8	-17	-22	-14	-11	2	2
35	4	-8	25	13	5	-11	-21	-27	-16	-12	6	2
40	3	-5	31	18	3	-17	-28	-34	-19	-9	14	9
45	4	6	38	22	0	-24	-37	-41	-23	-2	24	22
50	9	24	50	30	-4	-31	-46	-46	-23	6	31	35
55	21	44	63	37	-6	-39	-52	-46	-17	10	36	46
60	42	62	70	35	-8	-47	-55	-38	-8	12	46	53

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 8b. W-E Winds 25 to 60 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40 DEGREES N												
25	26	19	13	14	-1	-3	-9	-11	-5	2	12	18
30	56	35	42	24	5	-3	-14	-13	-11	8	33	34
35	77	47	63	31	8	-6	-21	-17	-16	12	48	47
40	88	54	76	34	7	-10	-29	-23	-20	16	57	58
45	90	63	81	34	4	-16	-36	-30	-22	17	63	69
50	83	77	78	35	-1	-22	-44	-38	-22	16	65	79
55	77	89	70	37	-7	-25	-51	-50	-20	17	67	85
60	82	89	58	35	-11	-25	-59	-63	-16	21	69	83
50 DEGREES N												
25	24	29	12	18	-8	-7	-10	-4	0	2	12	33
30	44	41	26	19	-5	-12	-15	-8	0	13	23	55
35	62	52	37	24	-7	-15	-19	-13	-1	19	34	73
40	80	61	47	31	-13	-18	-21	-19	-2	21	44	85
45	88	71	53	45	-22	-20	-27	-24	-6	23	56	101
50	79	84	55	66	-24	-24	-40	-24	-13	30	66	119
55	64	94	54	76	-18	-26	-54	-21	-21	35	68	121
60	60	67	47	65	-5	-23	-64	-27	-24	31	64	89
60 DEGREES N												
25	49	17	14	10	-2	-8	-8	-6	-1	10	21	15
30	63	21	9	13	-8	-11	-11	-7	-4	18	23	32
35	70	28	8	14	-11	-14	-15	-8	-5	26	30	50
40	68	36	13	14	-10	-15	-18	-11	-4	34	41	72
45	68	47	17	11	-9	-17	-23	-15	-2	40	54	86
50	73	57	19	6	-9	-20	-27	-23	2	42	61	85
55	71	64	25	0	-11	-24	-34	-33	4	38	55	74
60	56	63	46	-2	-11	-31	-46	-43	3	30	41	56
70 DEGREES N												
25	-1	-21	8	-25	-3	-10	-9	-3	-4	2	2	-8
30	14	-18	4	7	-8	-8	-11	-4	-3	7	9	12
35	27	-6	-4	27	-11	-7	-14	-5	-2	14	10	26
40	39	17	-14	34	-12	-6	-19	-7	1	22	5	33
45	45	42	-28	33	-12	-10	-22	-11	4	26	-2	31
50	41	66	-42	28	-14	-20	-25	-16	8	24	-5	23
55	30	83	-42	22	-18	-32	-26	-19	11	18	-2	13
60	20	79	-22	12	-20	-38	-36	-23	9	9	4	9
80 DEGREES N												
25	15	8	4	29	-6	-7	-5	-3	-4	-1	-5	-30
30	1	-7	0	37	-19	-7	-3	-4	2	-7	2	-27
35	-8	-11	-5	40	-26	-5	-4	-5	4	-4	1	-26
40	-11	-2	-13	39	-25	0	-8	-5	4	13	-12	-27
45	-11	14	-22	34	-25	2	-13	-7	1	25	-28	-29
50	-9	28	-26	27	-31	-4	-16	-11	0	23	-32	-30
55	-3	33	-21	21	-32	-14	-19	-14	3	16	-18	-25
60	7	25	-10	14	-21	-16	-20	-16	6	11	-2	-18

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 9a. W-E Winds 25 to 60 km. Based on S. Hemisphere data from all longitudes. Winds to the east are positive in m/s

KM	LATITUDE (DEGREES S) 0	10	20	30	40	50	60	70	80
JANUARY 1									
25	-17	-18	-	-	-9	-	-	-	2
30	-13	-26	-	-	-26	-	-	-	-1
35	-14	-36	-	-	-35	-	-	-	-4
40	-20	-49	-	-	-38	-	-	-	-7
45	-35	-59	-53	-35	-34	-27	-34	-27	-10
50	-51	-53	-64	-39	-32	-31	-39	-25	-15
55	-50	-30	-60	-46	-38	-41	-43	-27	-21
60	-24	-3	-	-	-55	-	-	-	-25
FEBRUARY 1									
25	-14	-17	-	-16	3	-	-	-	2
30	-28	-29	-	-22	9	-	-	-	1
35	-36	-38	-	-29	10	-	-	-	0
40	-41	-46	-	-38	6	-	-	-	1
45	-36	-44	-44	-45	-4	-8	-7	-7	2
50	-15	-28	-42	-48	-22	-14	-14	-9	1
55	9	-8	-36	-45	-42	-22	-25	-12	-1
60	23	7	-	-37	-57	-	-	-	-4
MARCH 1									
25	-30	-15	-	-13	-	-	-	-	-2
30	-36	-33	-	-16	-	-	-	-	-1
35	-34	-40	-	-17	-	-	-	-	-3
40	-20	-37	-	-16	-	-	-	-	-6
45	-3	-20	-	-16	-	-	-	-	-8
50	12	0	-	-17	-	-	-	-	-6
55	22	11	-	-18	-	-	-	-	-2
60	32	18	-	-13	-	-	-	-	2
APRIL 1									
25	-10	-18	-	-6	-	-	-	-	-
30	8	-26	-	-4	-	-	-	-	-
35	20	-22	-	0	-	-	-	-	-
40	26	-2	11	6	29	50	51	28	-
45	28	21	17	11	30	57	59	-	-
50	35	34	21	14	29	64	52	-	-
55	44	40	19	17	27	65	40	-	-
60	47	36	10	23	-	-	-	-	-

Table 9a. W-E Winds 25 to 60 km (Contd.)

KM	LATITUDE (DEGREES S) 0	10	20	30	40	50	60	70	80
MAY 1									
25	-7	-18	-	0	-	-	-	-	30
30	1	-8	-	6	-	-	-	-	41
35	9	2	-	15	27	-	-	-	45
40	17	16	20	27	41	44	30	18	40
45	28	24	28	43	56	49	25	-	-
50	38	25	37	59	70	52	25	-	-
55	43	30	46	72	80	48	19	-	-
60	38	40	51	83	-	-	-	-	-
JUNE 1									
25	-21	-16	-	8	37	-	-	-	11
30	-14	-7	-	12	34	-	-	-	11
35	-7	2	-	24	44	-	-	-	-
40	-2	11	-	46	67	-	-	-	-
45	1	16	-	71	98	-	-	-	-
50	2	20	-	91	123	-	-	-	-
55	5	26	-	98	132	-	-	-	-
60	11	31	-	90	117	-	-	-	-
JULY 1									
25	-24	-17	-	21	63	-	-	-	32
30	-18	-5	-	13	46	-	-	-	29
35	-15	2	-	15	45	-	-	-	24
40	-16	2	-12	28	60	34	87	91	14
45	-18	-1	-12	52	89	72	90	69	-
50	-17	-2	-1	74	116	88	90	36	-
55	-9	5	20	87	124	-	-	-	-
60	5	18	-	80	120	-	-	-	-
AUGUST 1									
25	-22	-13	-	-3	9	-	-	-	31
30	-23	-5	-	4	35	-	-	-	24
35	-23	-2	-	16	62	-	-	-	20
40	-22	-4	-6	31	94	80	45	35	19
45	-19	-8	-2	46	121	104	64	46	21
50	-14	-12	6	57	130	88	53	33	21
55	-8	-11	12	63	119	-	-	-	-
60	-1	-8	-	69	99	-	-	-	-

Table 9a. W-E Winds 25 to 60 km (Contd.)

KM	0	10	20	30	40	50	60	70	80
				LATITUDE (DEGREES S)					
SEPTEMBER 1									
25	-1	-22	-	19	12	-	-	-	26
30	-25	-11	-	17	13	-	-	-	32
35	-35	-5	-	19	23	-	-	-	35
40	-28	-3	-	26	40	-	-	-	33
45	-12	-3	-	34	68	-	-	-	28
50	3	-4	-	40	98	-	-	-	18
55	14	-3	-	47	113	-	-	-	9
60	24	7	-	60	105	-	-	-	5
OCTOBER 1									
25	-9	-23	-	-1	28	-	-	-	64
30	-13	-16	-	-2	35	-	-	-	79
35	-12	-9	-	2	37	-	-	-	85
40	-8	-2	-8	12	29	24	-	38	82
45	4	4	7	27	24	45	-	35	70
50	22	10	24	42	29	84	-	30	51
55	35	22	-	47	35	78	39	24	32
60	40	36	-	38	33	-	-	-	16
NOVEMBER 1									
25	17	-17	4	-11	6	-	-	-	23
30	16	-15	-8	-7	-5	-	-	-	12
35	17	-10	-11	-3	-10	-	-	-	4
40	17	-3	-6	1	-10	-21	-	-1	0
45	23	2	3	4	-9	-25	-	-4	-4
50	32	1	8	2	-10	-25	-	-7	-7
55	39	-3	7	-2	-12	-18	-16	-11	-7
60	39	-7	2	-6	-13	-	-	-	-2
DECEMBER 1									
25	-20	-18	-17	-8	-10	-	-	-	-3
30	-10	-10	-17	-9	-22	-	-	-	-5
35	-4	-8	-19	-13	-29	-	-	-	-5
40	-2	-11	-23	-21	-32	-	-	-	-4
45	-7	-23	-30	-30	-30	-	-	-	-5
50	-16	-38	-37	-38	-27	-	-	-	-11
55	-18	-41	-40	-43	-25	-	-	-	-18
60	-9	-29	-40	-47	-26	-	-	-	-21

Table 9b. W-E Winds 25 to 60 km. Based on S. Hemisphere data from all longitudes. Winds to the east are positive in m/s. Values apply to the first day of each month

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES S												
25	-17	-14	-30	-10	-7	-21	-24	-22	-1	-9	17	-20
30	-13	-28	-36	8	1	-14	-16	-23	-25	-13	16	-10
35	-14	-36	-34	20	9	-7	-15	-23	-35	-12	17	-4
40	-20	-41	-20	26	17	-2	-16	-22	-28	-8	17	-2
45	-35	-36	-3	28	28	1	-16	-19	-12	4	23	-7
50	-51	-15	12	35	38	2	-17	-14	3	22	32	-16
55	-50	9	22	44	43	5	-9	-8	14	35	39	-18
60	-24	23	32	47	38	11	5	-1	24	40	39	-9
10 DEGREES S												
25	-18	-17	-15	-18	-18	-16	-17	-13	-22	-23	-17	-18
30	-26	-29	-33	-26	-8	-7	-5	-5	-11	-16	-15	-10
35	-36	-38	-40	-22	2	2	2	-2	-5	-9	-10	-8
40	-49	-46	-37	-2	16	11	2	-4	-3	-2	-3	-11
45	-59	-44	-20	21	24	16	-1	-8	-3	4	2	-23
50	-53	-26	0	34	25	20	-2	-12	-4	10	1	-38
55	-30	-8	11	40	30	26	5	-11	-3	22	-3	-41
60	-3	7	18	36	40	31	18	-8	7	36	-7	-29
20 DEGREES S												
25	-	-	-	-	-	-	-	-	-	-	4	-17
30	-	-	-	-	-	-	-	-	-	-	-8	-17
35	-	-	-	-	-	-	-	-	-	-	-11	-19
40	-	-	-	11	20	-	-12	-6	-	-8	-6	-23
45	-53	-44	-	17	28	-	-12	-2	-	7	3	-30
50	-64	-42	-	21	37	-	-1	6	-	24	8	-37
55	-60	-36	-	19	46	-	20	12	-	-	7	-40
60	-	-	-	10	51	-	-	-	-	-	2	-40
30 DEGREES S												
25	-	-16	-13	-6	0	8	21	-3	19	-1	-11	-8
30	-	-22	-16	-4	6	12	13	4	17	-2	-7	-9
35	-	-29	-17	0	15	24	15	16	19	2	-3	-13
40	-	-38	-16	6	27	46	28	31	26	12	1	-21
45	-35	-45	-16	11	43	71	52	46	34	27	4	-30
50	-39	-48	-17	14	59	91	74	57	40	42	2	-38
55	-46	-45	-18	17	72	98	87	63	47	47	-2	-43
60	-	-37	-13	23	83	90	80	69	60	38	-6	-47

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 9b. W-E Winds 25 to 60 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40 DEGREES S												
25	-9	3	-	-	-	37	63	9	12	28	6	-10
30	-26	9	-	-	-	34	46	35	13	35	-5	-22
35	-35	10	-	-	27	44	45	62	23	37	-10	-29
40	-38	6	-	29	41	67	60	94	40	29	-10	-32
45	-34	-4	-	30	56	98	89	121	68	24	-9	-30
50	-32	-22	-	29	70	123	116	130	98	29	-10	-27
55	-38	-42	-	27	80	132	124	119	113	35	-12	-25
60	-55	-57	-	-	-	117	120	99	105	33	-13	-26
50 DEGREES S												
25	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	50	44	-	34	80	-	24	-21	-
45	-27	-8	-	57	49	-	72	104	-	45	-25	-
50	-31	-14	-	64	52	-	88	88	-	84	-25	-
55	-41	-22	-	65	48	-	-	-	-	78	-18	-
60	-	-	-	-	-	-	-	-	-	-	-	-
60 DEGREES S												
25	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	51	30	-	87	45	-	-	-	-
45	-34	-7	-	59	25	-	90	64	-	-	-	-
50	-29	-14	-	52	25	-	90	53	-	-	-	-
55	-43	-25	-	40	19	-	-	-	-	39	-16	-
60	-	-	-	-	-	-	-	-	-	-	-	-
70 DEGREES S												
25	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	28	18	-	91	35	-	38	-1	-
45	-27	-7	-	-	-	-	69	46	-	35	-4	-
50	-25	-9	-	-	-	-	36	33	-	30	-7	-
55	-27	-12	-	-	-	-	-	-	-	24	-11	-
60	-	-	-	-	-	-	-	-	-	-	-	-
80 DEGREES S												
25	2	2	-2	-	30	11	32	31	26	64	23	-3
30	-1	1	-1	-	41	11	29	24	32	79	12	-5
35	-4	0	-3	-	45	-	24	20	35	85	4	-5
40	-7	1	-6	-	40	-	14	19	33	82	0	-4
45	-10	2	-8	-	-	-	-	21	28	70	-4	-5
50	-15	1	-6	-	-	-	-	21	18	51	-7	-11
55	-21	-1	-2	-	-	-	-	-	9	32	-7	-18
60	-25	-4	2	-	-	-	-	-	5	16	-2	-21

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 10a. W-E Winds 60 to 130 km. Based on data from all longitudes with S. Hemisphere data shifted six months in time. Winds to the east are positive in m/s

	LATITUDE (DEGREES N)							
KM	0	10	20	30	40	50	60	70
JANUARY 1								
60	-13	18	36	63	96	62	34	-8
65	16	34	50	76	105	68	32	1
70	26	30	50	81	108	70	33	11
75	20	19	39	66	102	68	33	12
80	13	14	23	34	80	62	31	7
85	7	11	9	12	54	47	26	3
90	-9	-14	-8	5	31	28	-	-
95	-28	-39	-23	0	17	14	-	-
100	-28	-40	-28	-8	7	8	-	-
105	-7	-20	-18	-9	1	-	-	-
110	17	1	0	2	1	-	-	-
115	31	18	20	11	1	-	-	-
120	-	-	-	7	-	-	-	-
125	-	-	-	-12	-	-	-	-
130	-	-	-	-33	-	-	-	-
FEBRUARY 1								
60	13	2	13	66	80	53	3	19
65	21	5	1	73	82	19	15	5
70	9	-2	-12	66	83	9	28	-5
75	-13	-14	-15	40	80	17	36	-2
80	-28	-18	-12	10	70	22	28	14
85	-32	-20	-15	-6	53	19	8	17
90	-31	-30	-29	-18	32	21	-	-
95	-23	-41	-36	-19	15	21	-	-
100	-3	-29	-16	5	14	8	-	-
105	22	8	17	39	17	-	-	-
110	37	41	34	36	6	-	-	-
115	37	49	27	0	-18	-	-	-
120	-	-	-	-27	-	-	-	-
125	-	-	-	-39	-	-	-	-
130	-	-	-	-50	-	-	-	-
MARCH 1								
60	23	13	46	60	64	50	62	-6
65	30	26	49	66	64	31	78	17
70	24	26	36	57	59	15	71	24
75	6	10	9	25	51	13	40	16
80	-12	-9	-13	-4	47	17	11	2
85	-22	-20	-19	-4	36	20	0	-6
90	-22	-36	-23	15	20	21	-	-
95	-13	-43	-34	17	17	19	-	-
100	7	-27	-48	0	32	13	-	-
105	26	7	-41	-8	20	-	-	-
110	30	27	-21	1	33	-	-	-
115	20	27	-7	12	-77	-	-	-
120	-	-	-	10	-	-	-	-
125	-	-	-	-1	-	-	-	-
130	-	-	-	-13	-	-	-	-

Table 10a. W-E Winds 60 to 130 km (Contd.)

KM	0	10	20	30	40	50	60	70
				LATITUDE (DEGREES N)				
APRIL 1								
60	46	42	39	24	29	60	-7	7
65	40	36	28	13	25	40	4	-1
70	10	4	0	-1	22	31	10	0
75	-25	-33	-23	-7	15	24	8	2
80	-42	-46	-28	-3	8	10	-1	-2
85	-40	-45	-25	5	0	-6	-8	-7
90	-34	-54	-32	0	-6	-18	-	-
95	-21	-52	-40	-16	-3	-20	-	-
100	-3	-25	-36	-30	6	-3	-	-
105	3	-3	-28	-31	12	-	-	-
110	-13	-20	-31	-26	3	-	-	-
115	-29	-44	-36	-22	-16	-	-	-
120	-	-	-	-21	-	-	-	-
125	-	-	-	-15	-	-	-	-
130	-	-	-	-8	-	-	-	-
MAY 1								
60	15	-4	-3	-7	-8	-3	-8	-18
65	18	-12	-15	-14	-10	10	-1	-14
70	22	-11	-23	-20	-18	13	1	-9
75	20	-3	-17	-15	-25	3	-1	-2
80	10	5	3	9	-27	-11	-3	7
85	-4	5	17	26	-23	-19	-5	11
90	-15	-5	16	29	-10	-18	-	-
95	-22	-15	6	25	20	-6	-	-
100	-22	-19	-2	18	57	27	-	-
105	-11	-10	-3	4	73	-	-	-
110	10	9	5	-4	56	-	-	-
115	32	30	19	-1	19	-	-	-
120	-	-	-	-1	-	-	-	-
125	-	-	-	-12	-	-	-	-
130	-	-	-	-24	-	-	-	-
JUNE 1								
60	-1	-23	-36	-44	-25	-21	-30	-43
65	5	-10	-38	-48	-32	-15	-36	-42
70	7	-1	-32	-40	-43	-11	-36	-32
75	7	6	-12	-18	-46	-10	-37	-19
80	3	11	10	9	-30	-16	-41	-11
85	-8	6	17	24	-3	-23	-35	-10
90	-23	-7	17	34	28	-13	-	-
95	-32	-8	21	42	54	12	-	-
100	-29	1	22	40	60	18	-	-
105	-11	5	11	15	36	-	-	-
110	14	3	2	-12	-7	-	-	-
115	33	13	8	-18	-43	-	-	-
120	-	-	-	-7	-	-	-	-
125	-	-	-	-4	-	-	-	-
130	-	-	-	-4	-	-	-	-

Table 10a. W-E Winds 60 to 130 km (Contd.)

	LATITUDE (DEGREES N)							
KM	0	10	20	30	40	50	60	70
JULY 1								
60	-13	-6	-14	-55	-56	-53	-46	-41
65	16	10	9	-57	-60	-64	-57	-46
70	26	16	15	-48	-53	-63	-53	-28
75	20	16	15	-18	-31	-48	-35	1
80	13	10	21	22	2	-24	-16	19
85	7	10	25	37	24	-4	-5	14
90	-9	0	12	22	34	8	-	-
95	-28	-14	-6	1	43	18	-	-
100	-28	-21	-12	-1	58	43	-	-
105	-7	1	-3	0	65	-	-	-
110	17	22	7	0	49	-	-	-
115	31	30	12	-5	13	-	-	-
120	-	-	-	-7	-	-	-	-
125	-	-	-	-13	-	-	-	-
130	-	-	-	-19	-	-	-	-
AUGUST 1								
60	13	13	-23	-38	-59	-41	-38	-22
65	21	20	-12	-26	-64	-63	-45	-32
70	9	6	-14	-12	-51	-70	-56	-39
75	-13	-18	-22	1	-29	-55	-59	-38
80	-28	-30	-18	7	-9	-23	-38	-18
85	-32	-29	-8	9	2	7	7	3
90	-31	-21	5	14	15	22	-	-
95	-23	-5	23	31	27	18	-	-
100	-3	19	45	50	33	11	-	-
105	22	36	55	63	28	-	-	-
110	37	40	46	52	16	-	-	-
115	37	32	26	26	-4	-	-	-
120	-	-	-	-1	-	-	-	-
125	-	-	-	-17	-	-	-	-
130	-	-	-	-32	-	-	-	-
SEPTEMBER 1								
60	23	21	18	-6	-17	-19	-4	6
65	30	26	22	4	-13	-20	-12	-2
70	24	22	20	14	-9	-20	-18	-13
75	6	12	17	26	-1	-13	-21	-22
80	-12	3	17	38	17	4	-13	-16
85	-22	0	17	38	30	22	6	6
90	-22	4	19	24	29	27	-	-
95	-13	15	25	12	22	20	-	-
100	7	28	29	6	19	12	-	-
105	26	31	20	-6	9	-	-	-
110	30	19	-1	-28	-21	-	-	-
115	20	1	-19	-44	-55	-	-	-
120	-	-	-	-42	-	-	-	-
125	-	-	-	-25	-	-	-	-
130	-	-	-	-9	-	-	-	-

Table 10a. W-E Winds 60 to 130 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70
OCTOBER 1								
60	46	41	15	25	29	43	16	6
65	40	34	19	23	29	27	11	-4
70	10	8	16	22	18	13	9	-13
75	-25	-18	6	25	5	7	5	-16
80	-42	-25	1	26	7	9	5	-11
85	-40	-12	8	25	18	13	8	-1
90	-34	3	22	27	24	8	-	-
95	-21	14	28	21	23	-2	-	-
100	-3	15	15	-5	28	-5	-	-
105	3	2	-11	-39	29	-	-	-
110	-13	-17	-27	-43	5	-	-	-
115	-29	-27	-25	-21	-39	-	-	-
120	-	-	-	-5	-	-	-	-
125	-	-	-	-16	-	-	-	-
130	-	-	-	-32	-	-	-	-
NOVEMBER 1								
60	15	33	51	63	73	56	22	2
65	18	43	46	68	65	58	29	9
70	22	52	36	64	52	46	24	8
75	20	42	27	56	37	29	13	-1
80	10	20	20	45	26	22	7	-4
85	-4	2	17	45	26	24	10	2
90	-15	-2	19	45	29	22	-	-
95	-22	-5	18	38	20	7	-	-
100	-22	-10	9	21	-4	-13	-	-
105	-11	-10	-3	-2	-19	-	-	-
110	10	2	-8	-19	-15	-	-	-
115	32	19	-1	-30	-9	-	-	-
120	-	-	-	-28	-	-	-	-
125	-	-	-	-17	-	-	-	-
130	-	-	-	-2	-	-	-	-
DECEMBER 1								
60	-1	23	51	68	85	67	10	-7
65	5	19	41	61	70	54	13	-1
70	7	9	21	51	53	43	22	10
75	7	-3	0	42	47	38	25	15
80	3	-12	-8	32	46	36	21	9
85	-8	-16	-6	23	40	31	14	0
90	-23	-22	-6	11	37	20	-	-
95	-32	-36	-18	-3	37	10	-	-
100	-29	-43	-32	-19	31	11	-	-
105	-11	-21	-24	-25	17	-	-	-
110	14	20	5	-11	9	-	-	-
115	33	41	31	16	4	-	-	-
120	-	-	-	34	-	-	-	-
125	-	-	-	37	-	-	-	-
130	-	-	-	38	-	-	-	-

Table 10b. W-E Winds 60 to 130 km. Based on data from all longitudes with S. Hemisphere data shifted six months in time. Winds to the east are positive in m/s. Values apply to the first day of each month

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES N												
60	-13	13	23	46	15	-1	-13	13	23	46	15	-1
65	16	21	30	40	18	5	16	21	30	40	16	5
70	26	9	24	10	22	7	26	9	24	10	22	7
75	20	-13	6	-25	20	7	20	-13	6	-25	20	7
80	13	-28	-12	-42	10	3	13	-28	-12	-42	10	3
85	7	-32	-22	-40	-4	-8	7	-32	-22	-40	-4	-8
90	-9	-31	-22	-34	-15	-23	-9	-31	-22	-34	-15	-23
95	-28	-23	-13	-21	-22	-32	-28	-23	-13	-21	-22	-32
100	-28	-3	7	-3	-22	-29	-28	-3	7	-3	-22	-29
105	-7	22	26	3	-11	-11	-7	22	26	3	-11	-11
110	17	37	30	-13	10	14	17	37	30	-13	10	14
115	31	37	20	-29	32	33	31	37	20	-29	32	33
10 DEGREES N												
60	18	2	13	42	-4	-23	-6	13	21	41	33	23
65	34	5	26	36	-12	-10	10	20	26	34	43	19
70	30	-2	26	4	-11	-1	16	6	22	8	52	9
75	19	-14	10	-33	-3	6	16	-18	12	-18	42	-3
80	14	-18	-9	-46	5	11	10	-30	3	-25	20	-12
85	11	-20	-20	-45	5	6	10	-29	0	-12	2	-16
90	-14	-30	-36	-54	-5	-7	0	-21	4	3	-2	-22
95	-39	-41	-43	-52	-15	-8	-14	-5	15	14	-5	-36
100	-40	-29	-27	-25	-19	1	-21	19	28	15	-10	-43
105	-20	8	7	-3	-10	5	1	36	31	2	-10	-21
110	1	41	27	-20	9	3	22	40	19	-17	2	20
115	18	49	27	-44	30	13	30	32	1	-27	19	41
20 DEGREES N												
60	36	13	46	39	-3	-36	-14	-23	18	15	51	51
65	50	1	49	28	-15	-38	9	-12	22	19	46	41
70	50	-12	36	0	-23	-32	15	-14	20	16	36	21
75	39	-15	9	-23	-17	-12	15	-22	17	6	27	0
80	23	-12	-13	-28	3	10	21	-18	17	1	20	-8
85	9	-15	-19	-25	17	17	25	-8	17	8	17	-6
90	-8	-29	-23	-32	16	17	12	5	19	22	19	-6
95	-23	-36	-34	-40	6	21	-6	23	25	28	18	-18
100	-28	-16	-48	-36	-2	22	-12	45	29	15	9	-32
105	-18	17	-41	-28	-3	11	-3	55	20	-11	-3	-24
110	0	34	-21	-31	5	2	7	46	-1	-27	-8	5
115	20	27	-7	-36	19	8	12	26	-19	-25	-1	31
30 DEGREES N												
60	63	66	60	24	-7	-44	-55	-38	-6	25	63	68
65	76	73	66	13	-14	-48	-57	-26	4	23	68	61
70	81	66	57	-1	-20	-40	-48	-12	14	22	64	51
75	66	40	25	-7	-15	-18	-18	1	26	25	56	42
80	34	10	-4	-3	9	9	22	7	38	26	45	32
85	12	-6	-4	5	26	24	37	9	38	25	45	23

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 10b. W-E Winds 60 to 130 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
90	5	-18	15	0	29	34	22	14	24	27	45	11
95	0	-19	17	-16	25	42	1	31	12	21	38	-3
100	-8	5	0	-30	18	40	-1	50	6	-5	21	-19
105	-9	39	-8	-31	4	15	0	63	-6	-39	-2	-25
110	2	36	1	-26	-4	-12	0	52	-28	-43	-19	-11
115	11	0	12	-22	-1	-18	-5	26	-44	-21	-30	16
120	7	-27	10	-21	-1	-7	-7	-1	-42	-5	-28	34
125	-12	-39	-1	-15	-12	-4	-13	-17	-25	-16	-17	37
130	-33	-50	-13	-8	-24	-4	-19	-32	-9	-32	-2	38
40 DEGREES N												
60	56	80	64	29	-8	-25	-56	-59	-17	29	73	85
65	105	82	64	25	-10	-32	-60	-64	-13	29	65	70
70	108	83	59	22	-18	-43	-53	-51	-9	[illegible]	52	53
75	102	80	51	15	-25	-46	-31	-29	-1	5	37	47
80	80	70	47	8	-27	-30	2	-9	17	7	26	46
85	54	53	36	0	-23	-3	24	2	30	18	26	40
90	31	32	20	-6	-10	28	34	15	29	24	29	37
95	17	15	17	-3	20	54	43	27	22	23	20	37
100	7	14	32	6	57	60	58	33	19	28	-4	31
105	1	17	20	12	73	36	65	28	9	29	-19	17
110	1	6	-33	3	56	-7	49	16	-21	5	-15	9
115	1	-18	-77	-16	19	-43	13	-4	-55	-39	-9	4
50 DEGREES N												
60	62	53	50	60	-3	-21	-53	-41	-19	43	56	67
65	68	19	31	40	10	-15	-64	-63	-20	27	58	54
70	70	9	15	31	13	-11	-63	-70	-20	13	46	43
75	68	17	13	24	3	-10	-48	-55	-13	7	29	38
80	62	22	17	10	-11	-16	-24	-23	4	9	22	36
85	47	19	20	-6	-19	-23	-4	7	22	13	24	31
90	28	21	21	-18	-18	-13	8	22	27	8	22	20
95	14	21	19	-20	-6	12	18	18	20	-2	7	10
100	8	8	13	-3	27	18	43	11	12	-5	-13	11
60 DEGREES N												
60	34	3	62	-7	-8	-30	-46	-38	-4	16	22	10
65	32	15	78	4	-1	-36	-57	-45	-12	11	29	13
70	33	28	71	10	1	-36	-53	-56	-18	9	24	22
75	33	36	40	8	-1	-37	-35	-59	-21	5	13	25
80	31	28	11	-1	-3	-41	-16	-38	-13	5	7	21
85	26	8	0	-8	-5	-35	-5	7	6	8	10	14
70 DEGREES N												
60	-8	19	-6	7	-18	-43	-41	-22	6	6	2	-7
65	1	5	17	-1	-14	-42	-46	-32	-2	-4	9	-1
70	11	-5	24	0	-9	-32	-26	-39	-13	-13	8	10
75	12	-2	16	2	-2	-19	1	-38	-22	-16	-1	15
80	7	14	2	-2	7	-11	19	-18	-16	-11	-4	9
85	3	17	-6	-7	11	-10	14	3	6	-1	2	0

VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 11. Amplitude A (m/s) of the QBO of the W-E Wind (T = 32 months)

Height (km)	Latitude (°) 0	5	10	15	20	25	30	35
25	24.5	20.0	12.5	7.0	3.0	1.0	1.5	1.5
30	21.0	19.0	15.5	11.0	5.0	1.0	3.0	1.5
35	17.5	15.5	11.5	7.5	3.0	1.5	4.0	1.0
40	13.5	11.5	8.0	3.5	1.5	1.5	2.0	2.5
45	9.5	8.0	6.5	5.0	3.0	1.5	1.5	2.0
50	6.5	6.0	5.5	4.5	3.0	2.0	3.0	2.5
55	4.0	4.0	4.0	3.5	3.0	2.0	2.5	2.5
60	1.5	1.5	1.5	1.5	2.0	2.0	3.5	3.0

Table 12. Number of Months After 1 January 1966 M_0 When Maximum Flow From the West Occurs in the QBO of the W-E Wind (T = 32 Months)

Height (km)	Latitude (°) 0	5	10	15	20	25	30	35
25	9.5	9.5	9.5	10.0	11.0	12.5	17.5	24.5
30	4.0	4.0	4.5	5.5	7.5	12.0	17.0	24.0
35	-2.5	-2.5	-1.0	2.5	8.0	12.0	13.0	20.0
40	-7.5	-7.5	-6.5	-4.0	-1.0	4.0	6.5	4.5
45	-11.5	-11.0	-9.0	-7.0	-4.5	-2.0	0.0	0.5
50	-15.5	-12.5	-9.0	-7.0	-5.0	-4.0	-3.5	-4.0
55	-19.0	-18.0	-14.5	-10.5	-7.5	-5.5	-4.5	-4.0
60	-22.0	-20.0	-16.0	-12.0	-7.0	-4.0	-3.0	-5.0

Table 13. Low-latitude Sites. Comparison of W-E wind observations with 25 to 60 km model. MD - mean deviation (m/s) between observations and model; SD - standard deviation (m/s) of the distribution of differences from the model; G - number of four-hourly groups of local time 02-06 hr, 06-10 hr, etc., in which at least one observation occurs; and NRO - number of observations analysed

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SITES AT 0(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25			-01041004	-01011005	02042010					-04062009		
30			14031004	08041005	04052010					04092009		
35			-10031004	-18091005	16072010					01072008		
40			-19041004	18146023	-18052010					-10122008		
45	05146018		07141004	-10091005	09082010					-08092008		
50			-01101004	-03091005	04042010					01042008		
55	-30336006		02041004	03051005	-02062009					-06102007		
60			00061004	06041003	08062008					-06172006		
SITES AT 10(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	06082034	-01073044	02064027	04052041	02055058	03071037	00054027	-01081039	00061021	00061033	03065039	02085038
30	-05082035	-01073043	03074027	-05032043	-04095058	-09082039	00054028	02112039	03081021	-02071032	00074036	-06123035
35	00112036	-01103046	06104026	-02112043	00095057	-01092038	07064027	02083040	06132022	-03101032	02134036	-04123036
40	07122036	-03153047	-03114028	-07112043	02095056	-01062039	05114029	00133041	04072024	01121031	-04175034	04165037
45	00162031	-01133046	-04124025	-02122041	-03085053	05072038	00084029	-04103041	02092024	03111031	04115037	04155032
50	-18252025	00243035	10153020	-04152041	-09114043	-04111035	03124028	09163040	01152022	-03211028	06165034	-03175035
55	04172019	10183025	01143018	-03142031	-02144035	00161029	-01174025	-06162034	-02132021	-06171019	00174027	-12154031
60	00192013	07162014	-06153012	-05172019	-01094020	07121016	-14203014	-03221021	-04132014	-05181011	06183014	-09154016
SITES AT 20(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	00093086	-01064079	-03055052	-01044047	00053049	01046047	00034057	01035070	02044041	01054073	03056065	02065072
30	01153086	03094081	03075052	02064048	-02063050	-01046055	-01085061	-01055067	-02054044	-01054079	-06076077	-03125074
35	04183085	01115083	03075051	01074047	00073050	00066063	02065075	01065076	02054044	-01064079	00096077	-04195078
40	00213085	00155084	01105049	00094047	00053051	01086066	00116083	-01065085	-02064044	01094078	03136080	01205082
45	09246088	-03195081	-02145050	00113044	-01073049	01106060	00146082	-03074085	00084043	00104073	01156079	03235080
50	-01273074	-03215074	01114044	00143038	-01073047	02106055	02176077	-01094067	01113040	00104064	-03156076	-06234067
55	-15333046	04245048	-01113029	-03163028	00113037	-04096033	04256052	01113044	-03113022	00094041	-05146057	05274049
60	13251010	00243013	01202008	02152009	04173017	08165015	-04365020	-04122015	02142013	-02112010	10135017	05222016

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 14. S. Hemisphere Sites. Comparison of W-E wind observations with 25 to 60 km model. MD - mean deviation (m/s) between observations and model; SD - standard deviation (m/s) of the distribution of differences from the model; G - number of four-hourly groups of local time 02-06 hr, 06-10 hr, etc., in which at least one observation occurs; and NRO - number of observations analysed

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SITES AT -10(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	00066053	-01076065	03096039	05066049	02066022	04086028	02066047	02086051	00066029	-01056034	-02056038	02066059
30	-02066054	02076065	06106040	-09076054	-13076024	-05076028	-03096048	00076053	02066031	00056034	-03076048	-03066062
35	00076053	04076063	02086040	-08056055	-05086024	04066927	01116048	01106051	04086031	03086034	-02096041	-03086062
40	00096057	01096064	-08126040	-05156070	03056024	02086027	-03126050	00116052	03086033	02066037	-01086041	03106062
45	-03106069	-05176063	-05206041	01126056	-03116024	-03106026	-01136047	02136052	01066033	04106037	02096040	03146061
50	-08196054	-02216060	00186038	-04086055	-11146024	-03116026	00156047	-01116052	02136033	-02126037	01116039	-02156059
55	01236048	03176052	01156037	00096064	-05176021	-02186024	04166043	02146048	02166030	-03166032	-04146035	-03156058
60	03176025	-04126034	-10146021	-02056038	-03156019	01146020	03116027	-02146032	-06196023	02106019	03096025	03076029
SITES AT -30(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25		-02054010	02062007	00035012	00056015	-07103012	07232006	-07043006	02063006	-03132012	-01055013	00045015
30		03124010	-02022007	-01655015	-01076013	-05123014	-04202007	-02263005	04153007	-03122011	-05095010	01044014
35		-02173009	-01073007	02054014	03076017	-03203014	-07272008	01233005	-06173008	00122010	01135011	04053011
40		-01203009	-01043006	00106042	-01086016	-08163013	-01292008	-03243006	-02123008	-04132011	00105011	01064010
45	04186012	-04253009	03102006	01075014	01096015	-05173012	04172009	-03164007	-01153008	03136017	04075013	-01084011
50		-07324009	03102006	01135015	05166015	-09243010	-07172009	-06144007	-07163008	01162011	-03105013	-06104011
55	02266012	02344007	00082007	-10256026	02106017	-07133009	39406015	-12134007	-06343006	13226023	01135012	00105012
60		-03334006	-02202007	00163011	01156015	05173006	-09252007	00134007	-14293005	05262011	-06144010	-01044011
SITES AT -40(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	-03072002	04--1001				-15--1001	13--1001	06--1001		04093004	08--1001	-02--1001
30	-04142002	00--1001				07--1001	11--1001	08--1001		09183004	05--1001	-01--1001
35	-05202002	11--1001			06--1001	11--1001	30--1001	-06--1001		03163004	-01--1001	-07--1001
40	-17262002	05--1001		06136018	-08--1001	03--1001	-50656008	37--1001		16213004	-02--1001	00--1001
45	-13156019	07--1001			-04--1001	20352002	18402002	00--1001		-04116010	04--1001	-07--1001
50	-24--1001	11--1001				07172002	04--1001	17--1001	12--1001	-09203004	-03--1001	
55	10156019			03056012		-01--1001	-08106007	21--1001	22--1001	15222002	-03--1001	
60	-20--1001					24--1001	19--1001	-16--1001	17--1001	-14--1001		
SITES AT -80(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	01011002	00021002	-01--1001		06--1001	-05--1001	05--1001	00062003	-02022003	17332005	05122004	-01031003
30	-01011002	00001002	02--1001		-02--1001	00--1001	00--1001	-02062003	01072003	05332005	-03192003	03011002
35	00011002	01031002	-01--1001		00--1001			04112003	-02021002	17392006	09222002	-01001002
40	00051002	02021002	-02--1001		12--1001			-05121002	-01011002	10352006	05142002	00001002
45	03021002	03071002	-02--1001					-06--1001	-05--1001	06292006	07102002	02011002
50	-03041002	03021002	-06--1001					12--1001	-02--1001	10321004	04002002	
55	03061002	02--1001	03--1001						-08--1001	-08161003	07--1001	
60	-04221002	07--1001	-03--1001						-01--1001	07231003	01--1001	

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 15. N. American Sites. Comparison of W-E wind observations with 25 to 60 km model. MD - mean deviation (m/s) between observations and model; SD - standard deviation (m/s) of the distribution of differences from the model; G - number of four-hourly groups of local time 02-06 hr, 06-10 hr, etc., in which at least one observation occurs; and NRO - number of observations analysed

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SITES AT 30(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	00106210	00106372	00086253	00086251	01056255	00046257	-01046246	00036313	-01036258	-01036280	01076293	01096255
30	-02176222	00156376	-01126267	-02116259	-01066272	-02056280	-01056254	-01046327	00046269	-01056289	-02096312	-01166262
35	-01236222	-01226372	00176255	01146260	02066270	00056283	00066254	00056341	01056264	01076293	-01136314	00176262
40	-02276221	-03256359	-01216256	01136261	01156262	-01056285	00076253	01056340	00066258	-01086287	00156313	-01176258
45	-02286212	01266335	-01216246	-01136251	-02136250	-02066275	-01076244	00086327	00076238	-01096264	-02166306	-01216253
50	-03276196	00266309	-03196230	-01136232	-01186236	00086268	00076232	01086307	00096222	-01106242	-01196292	-02236246
55	-06266167	00236260	-02206191	-01146199	00136184	02086220	00096198	00106263	-01106189	-01106195	00186252	-01256213
60	01256093	-02306175	05216109	03156124	-02136120	-01106147	-01136145	00166160	01146126	-02166122	02206178	-10266129
SITES AT 40(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	-01106038	01126090	01156052	00106052	01056105	00036056	01026044	00046092	00056078	00066052	01086079	01096062
30	-01146044	02186101	-01136058	01126050	-02066107	00056058	00056047	00036089	01046085	-01076053	01096093	-02176063
35	02206044	03266100	00186060	00146053	01066109	-01056063	01056049	01066090	03076087	-03086056	02146093	00206063
40	00206044	00366097	-01216051	01166054	00066105	-01056063	00056056	00066090	02086085	-02106057	01166087	-01186064
45	02206043	02416085	03266057	02136056	-01076088	00056055	-02066056	00066072	00096080	-02106056	02166078	01186057
50	02216041	02426076	02256054	02106053	01076085	00096054	00086051	00066062	05106070	-02146055	03176072	02276051
55	-02186040	01306067	-06236048	00146042	01096077	-01076046	05096044	04086046	01106056	-06246045	05176053	-02276041
60	-09276036	06266054	-02196041	03216033	-03106054	-02166037	-06176031	-07216033	02176030	-05196028	10196039	06256038
SITES AT 50(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	-07071010	01091005		-04011002	-01064021	00022009	00022009	00022013	-01033015	-03042009	-01061006	-05251002
30	-06141010	07132008		02011002	00084022	-01032009	-01032010	-01032013	03043016	-07072009	-01081006	13--1001
35	-04181010	05182008		07031002	-01104020	01032009	00022010	-01042012	01033016	-08092009	00101006	21--1001
40	02271008	15302008		10011002	01114020	00022009	-02032010	00042011	-01033016	-10122009	-01061006	04211002
45	-01371006	00501003		07021002	-04113018	01032008	03062009	-02032011	01102015	-06072008	-01111005	-07--1001
50	-27471003	20781002		06041002	-04163016	00052008	-09212806	-03102008	01152011	-07092007	-04031002	
55	-27611003	20521002		-01071002	05201006	00022006	-20391005	-02082005	-16182005	-06111003	-03071003	
60	-54--1001	16301002		00021002	-04061003	03052004	06071003	25--1001	01041002	03--1001	10011002	

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 15. N. American Sites (Contd.)

SITES AT 60(+OR-5) DEGREES

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	00126054	-01166087	01146090	03126072	00056068	01026045	00036041	01036061	-01036053	00056072	00076090	-01146072
30	-03146054	-02206084	04146090	01146071	00076064	-01036043	-01036041	02046060	-02046053	-01066072	02106091	02196071
35	-06186054	-05236085	05146090	-02176070	01076057	-01036043	-01036040	00056058	-01066051	-02076071	04136086	02216069
40	-10186053	-03256083	06176085	-02166068	01076051	-01046043	00026040	02046055	00056050	-02086070	05146080	04226067
45	-07186051	-02266082	07246079	01146064	00076046	-02046042	00036041	-01076051	-01046049	-03086059	06166074	04226060
50	-02206048	00286077	07256074	01156062	01076046	-03036042	00046041	-01056048	-02056047	-03086053	05146064	04246057
55	01216042	02326064	06286060	03156054	01086044	-02076041	-01076041	-02066048	-03096045	02136046	07176051	04276050
60	-05216015	-03366043	-05216029	-04156028	-01106033	02076036	03086037	-06116038	03086035	05116023	-09136025	08566020

SITES AT 70(+OR-5) DEGREES

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25								01023006				
30								00023007				
35		09133003		-03--1001	00062002			00023007				
40		02065006		02121002	00044004			00042007				
45		-01085006		-03051002	04094004			0202200[illegible]				
50		05135006		01131002	00204004			-04--1001				
55		-01085006		-02101002	05214004							
60		-05215006		07131002	-02114004							

SITES AT 80(+OR-5) DEGREES

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	00303007	-02092008	-02092004	02063013	-06113017	02043033	01024035	01075044	00033030	00054018	01116040	01203014
30	00323008	-03132009	-01052004	-03133012	-02093018	03053033	-01044035	-02035044	03033030	00053019	-01136046	-06263017
35	-02623008	-05082008	-05112004	-01093012	-03093017	00063033	0003403[illegible]	00055042	-02033029	01083019	00136046	05283018
40	-07463007	-08082008	01022004	03072011	-03103015	02083030	01044032	-01155041	05053027	-10083019	03186044	-01303018
45	-01643007	-01052007	-04132004	-02052007	09083015	03113028	-03084030	01065038	-02052025	13123019	-04286039	03263016
50	-10072003	10152003	-03262004	-04052005	-02143015	10153025	01064023	01065029	00072020	-07133015	-03245032	-03313012
55	-12--1001			00121003	-04082006	-06102016	01134019	-03055024	-01062010	04123005	00125015	02283006
60	03--1001				-03092005	11142003	02081007	00125012	03172005	03041002	11214004	

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 16. European/W. Asian Sites. Comparison of W-E wind observations with 25 to 60 km model. MD - mean deviation (m/s) between observations and model; SD - standard deviation (m/s) of the distribution of differences from the model; G - number of four-hourly groups of local time 02-06 hr, 06-10 hr, etc., in which at least one observation occurs; and NRO - number of observations analysed

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SITES AT 30(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	-01052003	01--1001	-03093003	-01053006	01056255	00046257	-01046246	00036313	00036258	-02021002	01042002	01063004
30	03182003	11--1001	07103003	00083006	00066272	-02056280	-01056254	-01046327	01056269	-03021002	-02062002	-10183004
35	01222003	-12--1001	13183003	-02193006	02066270	00056283	00066254	00056341	03066264	04011002	-02092002	-21193004
40	-10282003	-08--1001	11163003	05173006	01156262	-01056285	00076253	01056340	03066250	-12031002	-13192002	-22193004
45	-08282003	-09--1001	13243003	02133006	-01136250	-02066275	-01076244	-01086327	02076238	-09041002	-06092002	-28373004
50	-10362003	-12--1001	10253003	-06153006	-01186236	00086268	00076232	01086307	02096222	00131002	-05072002	-19293004
55	-07342003	03--1001	14183003	04073005	00136184	02086220	00096198	00106263	01106189	02171002	-07132002	-12243004
60	-27--1001	11--1001	19292002	17203004	-02126120	-01106147	-01136145	00166160	04146126	-23--1001	-26--1001	-09212003
SITES AT 40(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25		-01102008	04081003		01046105	00036056	01026044	00046092	01056078	01022005	02054025	01053018
30		02092009	09081003		-01066107	00056058	00056047	00036089	01046085	-01042005	00064032	03063019
35		11172009	14112004		01066109	-01056063	01056049	01066090	04076087	00052005	07084033	10163019
40		08252009	12182004		00066105	00046063	00056056	00066090	03086085	03052005	02064029	05253017
45		07352008	09152004		00076088	00056055	-02066056	00066072	02086080	-05082005	04084030	09223015
50		07432009	04232004		01076085	00096054	00086051	-01066062	06096070	01062005	00134025	11253011
55		14262007	01102004		01096077	-01076046	05096044	04086046	02106056	03031004	-03134022	06212008
60		-02191005	-02442002		-03116054	-02166037	-06176031	-07216033	02176030	03101002	00263013	12082006
SITES AT 50(+OR-5) DEGREES												
KM	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO	MDSDGNRO
25	05163005	-01042004		02171004	-02064021	00022009	00022009	00022013	-01033015	01042006	00082011	00102013
30	01193005	-02052004		00251004	00094022	-01032009	-01032010	-01032013	03043016	-04092006	02123012	00152013
35	05233005	-07162004		01191004	-01114020	01032009	00022010	-01042012	01033016	03052006	03133013	-02202011
40	05273005	-06302004		03211004	02114020	00022009	-02032010	00042011	-01033016	-07082006	03173012	09192013
45	-02343005	-09282004		-03291004	-03123018	01032008	03062009	-02032011	02112015	-11152006	-07313011	07452013
50	05402003	00272004		-01241004	-04163016	00052008	-09212006	-03102008	03162011	-06182005	07253011	08342012
55	-04--1001				05191006	00022006	-20391005	-02082005	-14152005	-01031002	00153008	28392007
60					-04061003	03052004	06071003	25--1001	01041002	-05061002	-01--1001	-34--1001

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 16. European/W. Asian Sites (Contd.)

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SITES AT 60(+OR-5) DEGREES												
KM	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO
25	-04172017	-05142020	-05162021	-01114021	00056069	01026045	00036041	00036061	04036053	-04072007	02072018	-08102008
30	-05302016	-04162019	-06152021	01144021	-01086064	-01036043	-01036041	01040060	04036053	-07102007	06092018	-15102008
35	-08442016	-03112019	-16222021	03124021	01086057	-01036043	-01036040	00046058	04036051	-05052007	03112018	-11102007
40	-14542015	01172019	-09232021	04134021	01086051	-01046043	00026040	02046055	03046050	-01052006	03112018	01282007
45	-17632015	12192019	-13252021	05094021	00076046	-02046042	00036041	-01076051	00046049	02042005	05132018	13452007
50	-07562015	19232019	-09292021	05124020	01076046	-03036042	00046041	-01056048	00056047	01092806	06142017	00572007
55	02512013	26242014	-20342020	09133019	01086044	-02076041	-01076041	-02066048	-02096045	04092006	10192016	13622007
60	-05272007	31202006	-11281012	01133013	-01106033	02076036	03086037	-05106038	00086035	10182004	02252008	04402005
SITES AT 70(+OR-5) DEGREES												
KM	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO
25	00071005	-07131007						01023006				
30	-11151005	-17191007						00023007				
35	-08201005	-20261007			-04132002			00023007				
40	-08251005	-09171007			-03104004			00042007				
45	-08291004	-06181007			01144004			02022005				
50	-03231004	-13141007			-02254004			-04--1001				
55	-13241003	01191007			03234004							
60	-14221002	09211007			-03124004							
SITES AT 80(+OR-5) DEGREES												
KM	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO	MOSDGNRO
25			01--1001		-06113017	02043033	01024035	00065044	00033030	03042002	02102006	-03231003
30			02--1001		-05103018	03053033	-01044035	-02035044	03033030	02032002	-07182006	-23211003
35			-09--1001		-09123017	00063033	00034034	00055042	-01033029	01222002	-07192006	07321003
40			05--1001		-10153015	03083030	01044032	-01155041	05053027	-11212002	04392006	-06531003
45			-10--1001		02123015	03113028	-03084030	00065038	-03052025	49872002	-08682005	-02--1001
50			-28--1001		-09183015	10163025	02064023	01065029	00072020	-26--1001	-27412004	00--1001
55					-10122006	-06102016	01134019	-03055024	-01062010	00--1001		-03--1001
60					-06112005	12142003	02081007	00125012	03172005			

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 17. Comparison of W-E Wind Observations With 60 to 130 km Model. MD - mean deviation (m/s) between observations and model; SD - standard deviation (m/s) of the distribution of differences from the model; G - number of four-hourly groups of local time 02-06 hr, 06-10 hr, etc. in which at least one observation occurs; NR - number of observations analysed

SITES AT 10(+OR-5) DEGREES N OR S

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65	09	09203			02	23505	05	18304	-05	12202			-03	05203	12	27202	18	05103	08	28408	-08	19308	04	26509
70	05	16203			17	24505	16	04203					02	14203					00	13305	10	24204	-07	10508
75	-24	22203			09	30404	-21	27203					09	08203	01	--101			-08	22304			02	36509
80	-05	20203			-18	23303	-14	14203					-10	04203	48	--101			-07	03203			-21	28304
85	30	31203			23	28303	15	38203					05	51203					14	17203				
90	-14	37203	17	04203	-02	39407	-05	20304			56	--101	03	32305	-41	--101			-04	24412				
95			-05	15203	-11	24310	-15	31303			-11	39304	15	10204	-06	20204			05	43317			-05	35308
100			-11	12203	04	27311	00	58303			11	24305	-30	32204	24	92202			07	41319			-12	30313
105	22	--101	-02	12202	16	43311	29	23305			10	49304	14	20202	69100202				06	33318	-11	--101	-14	43313
110	39101202		10	18202	00	29311	-07	06305			-17	25202	-62	--101					-05	40318	-54	08102	06	37313
115	-19	43202	54	81202	02	33310	-17	37202			-56	--101							-04	33318	-05	--101	12	24313

SITES AT 20(+OR-5) DEGREES N OR S

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65	-15	20105	-03	42304	10	--101	22	25103	12	32102	01	13406	19	40406	-16	03102	-14	--101	-13	10102	-07	19304	07	23103
70			-22	33203			14	--101			-08	11203	08	27203	02	41305					-11	22202		
75													00	--101	-19	18514								
80													-48	--101	07	19512								
85															02	19203								
90																								
95					57	01102																		
100					-19	23203																		
105					-09	17203													-88	--101	-96	--101		
110					-29	34203													-57	--101	-46	39102		
115					17	05203													-76	--101	08	10102		

SITES AT 30(+OR-5) DEGREES N OR S

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65	-08	24320	-04	31537	-09	30414	-02	15424	07	11632	-01	11644	04	21430	07	25630	03	13420	01	18426	01	23644	02	26425
70	01	19207	06	23509	14	15405	-04	27413	10	22612	01	10513	-10	22304	01	16509	00	16411	-08	16306	07	31620	-05	28308
75	09	22205	07	40507	03	20304	-03	19308	-13	38509	-08	26307	04	--101	03	40305	-10	15205	06	14205	23	25616	03	11203
80	-19	12619	-18	24636	-13	47512	-03	22640	18	15610	22	32629	08	03618	12	24618	17	19638	11	10615	-15	39521	-02	28635
85			01	21650	-10	15624	09	26626	12	10622	-09	28652			-09	21623	06	20647	-43	54102	29	23627	07	22652
90	-03	02618	02	31649	06	20626	05	24645	01	08623	-10	23668	-04	13621	05	08628	-01	18649	03	10615	10	24632	-07	27664
95			-03	35649	10	29630	-02	22628	-13	15625	-04	22685	-29	30204	11	15629	-07	18648	-02	22405	-05	36635	-13	44680
100	-05	05618	-01	44643	-04	21623	-08	25641	-01	36521	01	28676	02	13622	-11	19627	-18	28643	05	26618	24	33530	-03	55681
105			37	46205	-08	27306	-32	80105	-19	60306	07	52327	-05	26203	22	40205	-06	29202	-20	46408	-13	43417	-13	54545
110			23	33205	10	21308	-12	30104	-17	44307	-04	45326	06112203		03	27207	26	49202	-15	39410	14	49419	-09	45543
115			-30	07204	11	43308	40	66104	03	20306	-07	45323	00	68204	06	23206	-12	59203	13	57408	-04	37417	05	50539
120			-01	03204	-01	40308	26	71105	-01	20306	12	44422	40	67202	-04	24205	-06	51204	10	60406	-17	36416	05	45535
125			-07	14205	12	29307	14	49105	01	26305	00	51416	01	--101	-07	26204	15	30102	00	33407	-07	29412	12	39533
130			-13	02204	-04	28205	11	35105	05	31305	-07	38415	-11	--101	-04	35204	00	42102	00	33304	-02	24411	07	37530

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 17. Comparison of W-E Wind Observations With 60 to 130 km Model (Contd.)

SITES AT 40(+OR-5) DEGREES N OR S

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65	16	28202	-03	26421	-06	23516	-01	12305	00	18630	06	15311	07	12412	-02	15610	01	05307	10	15306	-05	21520	00	29511
70	07	15202	-09	33418	-01	16612	06	05305	-01	14616	03	18407	00	14511	-08	10508	05	33405	-02	20305	05	13517	-15	23511
75	25	35202	01	42414	01	16617	-04	14305	-07	21613	-14	27307	-05	16611	-07	17508	-09	20405	-09	20203	-01	20413	-12	23511
80	09	29202	-02	34210	08	35615	00	09204	00	23610	-29	46202	18	36203	09	30406	13	--101	-15	68202	-08	16410	07	15407
85	-07	--101	-03	29304	08	24611	01	21204	-01	16508	03	49105	-09	--101	-23	53405	15	--101	-04	29303	-08	14410	01	22206
90	-36	16100	18	42202	00	06610	-03	10204	-09	44307	00	27105	76	--101	00	47404	16	13102	14	44202	-12	12407	-07	22204
95	39	05102	-15	27202	-23	21610	06	26102	03	23205	11	21207	10	41202			21	--101	-11	45203	02	28205	15	17204
100	60	40102	-64	92202	00	49204	10	45102	20	30205	05	28209	44	83202			53	77202	02	25204	-17	39205	26	22204
105	31	49102	-84	127202	17	05204	07	13102	16	46205	00	22209	50	106303			02	11202	36	48204	-09	30205	-13	19204
110	-37	38102	-64	109202	-20	48204	14	54102	12	46206	-09	37209	13	53304			-07	61202	08	44204	03	19205	14	44204
115	-47	--101	73	113202	-34	26204	25	61102	02	28206	-10	40209	30	85304			-04	50202	06	13204	06	24205	09	20204

SITES AT 50(+OR-5) DEGREES N OR S

KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65			-20	22606	-43	47606	-03	04606	-09	10606	09	10605							05	--101				
70			-05	05506	-36	40606	-07	07606	-05	16606	14	16506												
75			-05	05506	-23	25616	-05	05506	-09	10606	08	09605												
80			-03	05506	-10	11606	-11	13606	-01	02606	12	13606												
85			-06	07606	00	06606	-07	07606	03	04606	-01	01606												
90			02	02606	00	02606	05	06506	00	00606	-16	17606												
95	04	11660	00	09665	05	08667	03	28660	-01	07660	-02	11666	-02	05666	-07	08672	-01	05660	04	12654	01	14654	01	11666
100			-08	03606	-26	29606	-04	04606	01	01606	-13	15606												

SITES AT 60(+OR-5) DEGREES N OR S

KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65			05	33415	13	14203	00	20202	04	16202	00	08208	-15	28104	01	15511	-01	08304	-04	13304	-08	--101	-05	34308
70			05	35412	25	28203	27	--101	20	--101	-11	21102	09	--101	00	13512	04	16203	12	18202			00	41307
75			05	41413	00	10203	31	--101	-16	--101			07	--101	01	19515	09	01203	10	52202			06	30307
80			07	22412	-24	57202			33	--101	34	--101	-04	--101	-22	31513	-02	18202	49	70202			-03	54306
85			12	18408					31	--101	-14	34203	08	--101	09	22306	-49	--101	78	--101			-12	56102

SITES AT 70(+OR-5) DEGREES N OR S

KM	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR	MD	SDGNR
65			05	19509			-10	08102	-04	05404					03	08303	-33	--101	-05	--101	00	25202		
70			02	05509			-05	11102	06	20404					03	20303	-18	--101	46	--101	05	31202		
75			-23	35509			05	34102	-02	10404					-15	22303	-13	--101	-20	--101	-08	33202		
80			23	60508			-10	04102	-02	24404			13	14606	13	33609	-30	--101	-02	--101	42	80202		
85			-02	40508			-09	55102	11	25404			-02	02606	-04	30609	-53	--101	-03	--101	-81	--101		

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 18a. Temperatures (°K) 25 to 110 km

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70
JANUARY 1								
25	218	219	217	219	219	220	215	207
30	231	232	230	229	225	222	216	208
35	247	246	243	238	233	226	218	213
40	258	257	258	256	248	238	229	222
45	265	266	269	268	263	251	242	236
50	271	272	274	272	268	259	254	250
55	270	269	268	264	261	257	254	252
60	257	254	252	251	249	249	248	244
65	234	232	233	234	237	238	239	232
70	211	211	211	216	222	229	229	222
75	200	201	201	204	212	219	220	214
80	197	198	196	198	204	211	213	211
85	193	194	192	194	200*	207*	211	211
90	185	185	186*	189*	199*	208*	214	214
95	187	187*	190*	195*	203*	210*	214*	216*
100	204	203*	204*	204*	206*	210*	214*	215*
105	231	232*	228*	222*	217*	215*	217*	215*
110	273	276*	271*	259*	248*	240*	235*	229*
FEBRUARY 1								
25	218	218	218	219	218	217	217	214
30	231	232	231	228	224	219	220	217
35	246	245	244	239	234	228	224	221
40	258	259	258	254	250	243	234	227
45	268	270	271	268	265	257	247	237
50	273	275	275	271	269	263	256	247
55	270	268	266	264	261	259	254	249
60	253	250	247	247	247	247	245	240
65	233	228	228	230	234	237	235	228
70	213	210	213	217	221	226	226	217
75	201	201	205	209	213	217	218	211
80	195	195	199	201	205	211	213	207
85	193	192*	192	195	200	205	209	208
90	193	191*	189	190	195	202	207	208
95	200*	197*	197	197	197	200*	206*	209*
100	219*	215*	213	210	207	206*	210*	214*
105	251*	246*	237*	230*	225*	224*	228*	230*
110	296*	290*	278*	266*	258*	259*	261*	261*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W

Table 18a. Temperatures (°K) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70
			LATITUDE (DEGREES N)					
MARCH 1								
25	219	221	219	220	219	217	218	221
30	231	232	231	230	224	221	222	226
35	245	247	245	240	236	232	231	231
40	260	261	259	254	251	248	243	237
45	271	272	271	266	264	262	255	247
50	275	274	273	269	268	267	261	255
55	268	266	263	261	261	260	257	253
60	250	245	243	245	246	248	245	241
65	229	225	226	230	234	236	234	228
70	213	209	213	219	223	225	226	218
75	202	201	206	210	213	217	219	211*
80	197	196	200	202	203	206	211	207*
85	197	195	195	195	196	199	202	200*
90	198	193	190	189	191	192*	196*	199*
95	204*	199	195	195	196	197*	199*	205*
100	220*	214*	210	208	207	209*	215*	223*
105	255*	245*	236*	227	226	231*	245*	256*
110	306*	291*	275*	265	263	274*	291*	303*
APRIL 1								
25	220	221	222	222	222	222	223	221
30	233	233	235	232	229	229	228	222
35	248	249	247	244	242	243	237	229
40	262	262	260	256	256	258	252	243
45	273	272	271	269	269	270	266	259
50	275	274	273	271	272	272	271	267
55	267	265	264	263	263	265	262	261
60	248	246	246	247	249	249	245*	247*
65	227	227	231	235	236	237	237*	234*
70	209	210	218	222	224	225	226*	224*
75	200	200	206	212	213	214	215*	213*
80	199	199	201	203	201	199	202*	200*
85	202	200	199	197	191	186*	187*	187*
90	200	197	194	190	185	179*	181*	183*
95	199*	193	190*	189*	191	191*	193*	197*
100	209*	201*	195*	196*	201	210*	221*	232*
105	239*	229*	220*	216*	218	237*	263*	285*
110	293*	278*	264*	256*	262	284*	317*	344*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

Table 18a. Temperatures (°K) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70
				LATITUDE (DEGREES N)				
MAY 1								
25	221	221	223	223	224	225	225	223
30	234	233	235	233	231	232	232	231
35	250	250	248	245	246	248	246	238
40	262	262	260	259	262	264	261	255
45	270	271	271	271	273	277	275	270
50	274	274	275	275	276	278	278	278
55	269	267	265	265	267	268	270	271
60	252	252	251	252	251	253	254	257*
65	227	231	236	237	237	237	238*	241*
70	206	211	218	220	220	221	224*	229*
75	199	200	203	204	204	205	209*	211*
80	202	199	197	194	190	186	188*	188*
85	203	198	196	189	179	170	168*	168*
90	193	194	192	185	172	161*	159*	162*
95	187*	187*	187*	187	184	180*	180*	184*
100	193*	191*	194*	197*	204	212*	223*	234*
105	219*	215*	216*	220*	230	253*	279*	302*
110	269*	259*	255*	259*	274	304*	343*	373*
JUNE 1								
25	220	220	223	225	225	225	228	229
30	234	234	234	234	233	234	238	239
35	249	249	246	246	247	250	251	249
40	259	260	259	259	262	266	266	264
45	268	269	270	272	275	277	279	278
50	272	273	275	275	276	279	282	283
55	269	268	267	267	269	273	275	278
60	255	256	253	252	252	256	259	264*
65	232	234	233	232	232	236	240	245*
70	208	211	213	213	212	214	220*	225*
75	199	199	201	198	195	195	199*	201*
80	201	196	194	190	181	175	173*	173*
85	199	195	192	184	170	156	151*	149*
90	189	189	188	179	162	147	144*	145*
95	184*	186	189	189*	182	173	171*	173*
100	191*	193*	198*	206*	213	219	222*	226*
105	215*	214*	221*	232*	247	265	282*	295*
110	261*	253*	253*	264*	285	313	343*	366*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

Table 18a. Temperatures (°K) 25 to 110 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70
JULY 1								
25	218	220	222	224	224	227	230	231
30	231	233	233	232	235	238	239	238
35	247	245	244	244	246	250	252	251
40	258	256	256	257	259	264	267	266
45	265	265	268	268	271	274	278	279
50	271	271	273	272	274	276	281	285
55	270	269	267	266	267	270	276	281
60	257	257	253	250	251	256	262	267
65	234	234	230	226	229	234	241	246
70	211	211	209	207	207	211	217	222
75	200	200	200	197	191	189	191	194
80	197	196	195	189	178	168	165	164
85	193	194	191	183	167	153	144	140*
90	185	186	186	179	167	153	145	141*
95	187	189	193	195	192	184	174*	168*
100	204	204	206	214	222	221	216*	212*
105	231	229	229	237	246	255	258*	260*
110	273	265	260	265	276	293	306*	314*
AUGUST 1								
25	218	219	221	223	225	229	229	227
30	231	233	230	232	234	238	237	234
35	246	244	243	242	246	249	249	245
40	258	255	253	254	259	261	262	260
45	268	265	267	267	269	271	274	274
50	273	272	271	271	271	274	277	279
55	270	268	266	264	263	266	272	275
60	253	257	254	250	248	250	257	263
65	233	236	235	230	225	229	237	245
70	213	218	217	212	208	210	215	221
75	201	205	207	203	196	191	190	194
80	195	199	201	196	183	172	165	167
85	193	196	196	188	174	161	151	148
90	193	194	191	187	180	170	159	150
95	200*	199	197	197	199	194	181	170*
100	219*	216*	211*	208	212	211*	203*	193*
105	251*	247*	236*	226	225*	224*	220*	213*
110	296*	291*	276*	263	256*	254*	250*	241*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

Table 18a. Temperatures (°K) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70
				LATITUDE (DEGREES N)				
SEPTEMBER 1								
25	219	220	222	224	225	225	226	224
30	231	232	233	231	233	234	233	229
35	245	244	243	241	242	245	244	239
40	260	258	256	254	256	257	256	252
45	271	269	268	265	267	268	268	266
50	275	273	272	270	270	271	271	272
55	268	269	265	262	259	260	264	267
60	250	254	257	250	241	242	250	256
65	229	238	242	234	224	223	232	240
70	213	221	225	218	209	207	214	220
75	202	208	211	206	198	194	195	201
80	197	200	202	198	190	182	180	184
85	197	199	198	192	185	177	172	173*
90	198	199	197	193	191	185	177	173*
95	204*	207*	206*	205	203	196*	188*	179*
100	220*	225*	222*	216	211	204*	195*	184*
105	255*	257*	248*	236*	226*	216*	202*	187*
110	306*	307*	294*	278*	261*	244*	223*	198*
OCTOBER 1								
25	220	221	223	223	221	220	220	221
30	233	233	232	230	228	224	225	225
35	248	246	243	241	238	235	234	232
40	262	260	257	252	251	249	245	244
45	273	271	269	265	263	261	259	257
50	275	274	273	271	269	265	265	265
55	267	267	266	262	258	255	256	258
60	248	251	254	247	241	240	246	246
65	227	233	240	236	224	222	231	233
70	209	216	223	219	210	210	218	219
75	200	206	210	207	203	202	207	209
80	199	202	202	200	197	196	198	203
85	202	203	200	195	194	193	194	197*
90	200	200	198	195	197	198	197	196*
95	199*	203*	206*	205	202	201	199	195*
100	209*	217*	222*	221	217	209	201	193*
105	239*	247*	250*	249*	241	228*	209*	192*
110	293*	301*	299*	290*	276*	256*	227*	199*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

Table 18a. Temperatures (°K) 25 to 110 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70
NOVEMBER 1								
25	221	221	222	220	219	218	216	215
30	234	234	232	228	224	220	218	220
35	250	247	243	238	233	226	224	225
40	262	260	257	253	246	239	235	235
45	270	270	269	266	261	252	248	251
50	274	274	273	271	266	258	258	263
55	269	269	269	264	259	255	255	256
60	252	252	253	249	244	243	245	244
65	227	229	234	233	229	230	235	231
70	206	209	215	216	216	220	225	220
75	199	202	205	206	206	212	218	215
80	202	203	201	199	201	207	211	214
85	203	203	199	196	199	203	209	213*
90	193	192	191	194	200	207	211*	212*
95	187*	191	196	202	208	214	215*	212*
100	193*	200	210	219	222	220*	215*	209*
105	219*	227*	239*	245*	241*	231*	217*	206*
110	269*	282*	286*	284*	272*	253*	231*	212*
DECEMBER 1								
25	220	221	222	219	217	221	216	210
30	234	234	229	229	224	221	216	211
35	249	248	243	240	234	225	219	218
40	259	259	257	255	248	236	228	227
45	268	267	270	268	263	248	242	243
50	272	272	273	271	266	257	254	258
55	269	268	267	265	261	255	253	256
60	255	255	254	252	248	247	247	245
65	232	230	233	236	235	238	240	233
70	208	208	211	216	222	228	231	224
75	199	200	202	204	212	218	222	217
80	201	201	198	198	204	211	214	214
85	199	200	198	197	201	207	213	214
90	189	188	189	194	203	213	217	217
95	184*	184	187	196	207*	219*	222	219*
100	191*	193	197*	204*	212*	220*	221	217*
105	215*	220*	225*	225*	222*	219*	215*	211*
110	261*	270*	271*	263*	250*	238*	227*	216*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

Table 18b. Temperatures (°K) 25 to 110 km

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES N												
25	218	218	219	220	221	220	218	218	219	220	221	220
30	231	231	231	233	234	234	231	231	231	233	234	234
35	247	246	245	248	250	249	247	246	245	248	250	249
40	258	258	260	262	262	259	258	258	260	262	262	259
45	265	268	271	273	270	268	265	268	271	273	270	268
50	271	273	275	275	274	272	271	273	275	275	274	272
55	270	270	268	267	269	269	270	270	268	267	269	269
60	257	253	250	248	252	255	257	253	250	248	252	255
65	234	233	229	227	227	232	234	233	229	227	227	232
70	211	213	213	209	206	208	211	213	213	209	206	208
75	200	201	202	200	199	199	200	201	202	200	199	199
80	197	195	197	199	202	201	197	195	197	199	202	201
85	193	193	197	202	203	199	193	193	197	202	203	199
90	185	193	198	200	193	189	185	193	198	200	193	189
95	187	200*	204*	199*	187*	184*	187	200*	204*	199*	187*	184*
100	204	219*	220*	209*	193*	191*	204	219*	220*	209*	193*	191*
105	231	251*	255*	239*	219*	215*	231	251*	255*	239*	219*	215*
110	273	296*	306*	293*	269*	261*	273	296*	306*	293*	269*	261*
10 DEGREES N												
25	219	218	221	221	221	220	220	219	220	221	221	221
30	232	232	232	233	233	234	233	233	232	233	234	234
35	246	245	247	249	250	249	245	244	244	246	247	248
40	257	259	261	262	262	260	256	255	258	260	260	259
45	266	270	272	272	271	269	265	265	269	271	270	267
50	272	275	274	274	274	273	271	272	273	274	274	272
55	269	268	266	265	267	268	269	268	269	267	269	268
60	254	250	245	246	252	256	257	257	254	251	252	255
65	232	228	225	227	231	234	234	236	238	233	229	230
70	211	210	209	210	211	211	211	218	221	216	209	208
75	201	201	201	200	200	199	200	205	208	206	202	200
80	198	195	196	199	199	196	196	199	200	202	203	201
85	194	192*	195	200	198	195	194	196	199	203	203	200
90	185	191*	193	197	194	189	186	194	199	200	192	188
95	187*	197*	199	193	187*	186	189	199	207*	203*	191	184
100	203*	215*	214*	201*	191*	193*	204	216*	225*	217*	200	193
105	232*	246*	245*	229*	215*	214*	229	247*	257*	247*	227*	220*
110	276*	290*	291*	278*	259*	253*	265	291*	307*	301*	282*	270*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 18b. Temperatures (°K) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20 DEGREES N												
25	217	218	219	222	223	223	222	221	222	223	222	222
30	230	231	231	235	235	234	233	230	233	232	232	229
35	243	244	245	247	248	246	244	243	243	243	243	243
40	258	258	259	260	260	259	256	253	256	257	257	257
45	269	271	271	271	271	270	268	267	268	269	269	270
50	274	275	273	273	275	275	273	271	272	273	273	273
55	268	266	263	264	265	267	267	266	265	266	269	267
60	252	247	243	246	251	253	253	254	257	254	253	254
65	233	228	226	231	236	233	230	235	242	240	234	233
70	211	213	213	218	218	213	209	217	225	223	215	211
75	201	205	206	206	203	201	200	207	211	210	205	202
80	196	199	200	201	197	194	195	201	202	202	201	198
85	192	192	195	199	196	192	191	196	198	200	199	198
90	186*	189	190	194	192	188	186	191	197	198	191	189
95	190*	197	195	190*	187*	189	193	197	206*	206*	196	187
100	204*	213	210	195*	194*	198*	206	211*	222*	222*	210	197*
105	228*	237*	236*	220*	216*	221*	229	236*	248*	250*	239*	225*
110	271*	278*	275*	264*	255*	253*	260	276*	294*	299*	286*	271*
30 DEGREES N												
25	219	219	220	222	223	225	224	223	224	223	220	219
30	229	228	230	232	233	234	232	232	231	230	228	229
35	238	239	240	244	245	246	244	242	241	241	238	240
40	256	254	254	256	259	259	257	254	254	252	253	255
45	268	268	266	269	271	272	268	267	265	265	266	268
50	272	271	269	271	275	275	272	271	270	271	271	271
55	264	264	261	263	265	267	266	264	262	262	264	265
60	251	247	245	247	252	252	250	250	250	247	249	252
65	234	230	230	235	237	232	226	230	234	236	233	236
70	216	217	219	222	220	213	207	212	218	219	216	216
75	204	209	210	212	204	198	197	203	206	207	206	204
80	198	201	202	203	194	190	189	196	198	200	199	198
85	194	195	195	197	189	184	183	188	192	195	196	197
90	189*	190	189	190	185	179	179	187	193	195	194	194
95	195*	197	195	189*	187	189*	195	197	205	205	202	196
100	204*	210	208	196*	197*	206*	214	208	216	221	219	204*
105	222*	230*	227	216*	220*	232*	237	226	236*	249*	245*	225*
110	259*	266*	265	256*	259*	264*	265	263	278*	290*	284*	263*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 18b. Temperatures (°K) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40 DEGREES N												
25	219	218	219	222	224	225	224	225	225	221	219	217
30	225	224	224	229	231	233	235	234	233	228	224	224
35	233	234	236	242	246	247	246	246	242	238	233	234
40	248	250	251	256	262	262	259	259	256	251	246	248
45	263	265	264	269	273	275	271	269	267	263	261	263
50	268	269	268	272	276	276	274	271	270	269	266	266
55	261	261	261	263	267	269	267	263	259	258	259	261
60	249	247	246	249	251	252	251	248	241	241	244	248
65	237	234	234	236	237	232	229	225	224	224	229	235
70	222	221	223	224	220	212	207	208	209	210	216	222
75	212	213	213	213	204	195	191	196	198	203	206	212
80	204	205	203	201	190	181	178	183	190	197	201	204
85	200*	200	196	191	179	170	167	174	185	194	199	201
90	199*	195	191	185	172	162	167	180	191	197	200	203
95	203*	197	196	191	184	182	192	199	203	202	208	207*
100	206*	207	207	201	204	213	222	212	211	217	222	212*
105	217*	225*	226	218	230	247	246	225*	226*	241	241*	222*
110	248*	258*	263	262	274	285	276	256*	261*	276*	272*	250*
50 DEGREES N												
25	220	217	217	222	225	225	227	229	225	220	218	221
30	222	219	221	229	232	234	238	238	234	224	220	221
35	226	228	232	243	248	250	250	249	245	235	226	225
40	238	243	248	258	264	266	264	261	257	249	239	236
45	251	257	262	270	277	277	274	271	268	261	252	248
50	259	263	267	272	278	279	276	274	271	265	258	257
55	257	259	260	265	268	273	270	266	260	255	255	255
60	249	247	248	249	253	256	256	250	242	240	243	247
65	238	237	236	237	237	236	234	229	223	222	230	238
70	229	226	225	225	221	214	211	210	207	210	220	228
75	219	217	217	214	205	195	189	191	194	202	212	213
80	211	211	206	199	186	175	168	172	182	196	207	211
85	207*	205	199	186*	170	156	153	161	177	193	203	207
90	208*	202	192*	179*	161*	147	153	170	185	198	207	213
95	210*	200*	197*	191*	180*	173	184	194	196*	201	214	219*
100	210*	206*	209*	210*	212*	219	221	211*	204*	209	220*	220*
105	215*	224*	231*	237*	253*	265	255	224*	216*	228*	231*	219*
110	240*	259*	274*	284*	304*	313	293	254*	244*	256*	253*	238*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 18b. Temperatures (°K) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
60 DEGREES N												
25	215	217	218	223	225	228	230	229	226	220	216	216
30	216	220	222	228	232	238	239	237	233	225	218	216
35	218	224	231	237	246	251	252	249	244	234	224	219
40	229	234	243	252	261	266	267	262	256	245	235	228
45	242	247	255	266	275	279	278	274	268	259	248	242
50	254	256	261	271	278	282	281	277	271	265	258	254
55	254	254	257	262	270	275	276	272	264	256	255	253
60	248	245	245	249*	254	259	262	257	250	246	245	247
65	239	235	234	237*	238*	240	241	237	232	231	235	240
70	229	226	226	226*	224*	220*	217	215	214	218	225	231
75	220	218	219	215*	209*	199*	191	190	195	207	218	222
80	213	213	211	202*	188*	173*	165	165	180	198	211	214
85	211	209	202	187*	168*	151*	144	151	172	194	209	213
90	214	207	196*	181*	159*	144*	145	159	177	197	211*	217
95	214*	206*	199*	193*	180*	171*	174*	181	188*	199	215*	222
100	214*	210*	215*	221*	223*	222*	216*	203*	195*	201	215*	221
105	217*	228*	245*	263*	279*	282*	258*	220*	202*	209*	217*	215*
110	235*	261*	291*	317*	343*	343*	306*	250*	223*	227*	231*	227*
70 DEGREES N												
25	207	214	221	221	223	229	231	227	224	221	215	210
30	208	217	226	222	231	239	238	234	229	225	220	211
35	213	221	231	229	238	249	251	245	239	232	225	218
40	222	227	237	243	255	264	266	260	252	244	235	227
45	236	237	247	259	270	278	279	274	266	257	251	243
50	250	247	255	267	278	283	285	279	272	265	263	258
55	252	249	253	261	271	278	281	275	267	258	256	256
60	244	240	241	247*	257*	264*	267	263	256	246	244	245
65	232	228	228	234*	241*	245*	246	245	240	233	231	233
70	222	217	218	224*	229*	225*	222	221	220	219	220	224
75	214	211	211*	213*	211*	201*	194	194	201	209	215	217
80	211	207	207*	200*	188*	173*	164	167	184	203	214	214
85	211	208	200*	187*	168*	149*	140*	148	173*	197*	213*	214
90	214	208	199*	183*	162*	145*	141*	150	173*	196*	212*	217
95	216*	209*	205*	197*	184*	173*	168*	170*	179*	195*	212*	219*
100	215*	214*	223*	232*	234*	226*	212*	193*	184*	193*	209*	217*
105	215*	230*	256*	285*	302*	295*	260*	213*	187*	192*	206*	211*
110	229*	261*	303*	344*	373*	366*	314*	241*	198*	199*	212*	216*

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

Table 19. Mean Deviations of Observed Temperatures (°K) From the Model Followed by Standard Deviations (in brackets) and the Number of Observations at 25 to 55 km

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
FORT SHERMAN*												
25	-01(05)12	00(03)11	00(04)06	01(03)19	-01(02)26	00(01)20	-02(03)08	00(02)20	00(04)07	00(02)19	-01(02)17	00(02)14
30	-02(06)12	00(03)11	-02(04)06	01(04)19	01(04)25	01(03)20	-01(02)08	01(04)18	01(04)07	01(03)19	00(04)17	00(04)14
35	00(06)12	01(04)11	0[illegible](06)06	-01(08)19	-01(04)24	00(03)19	04(07)08	-02(06)19	-01(03)07	01(05)19	00(05)15	-01(04)16
40	-01(04)12	00(03)11	01(09)05	01(05)16	-01(04)26	-01(04)20	-01(02)07	-01(04)19	-01(03)07	-01(04)17	00(04)16	-01(05)13
45	00(05)11	01(04)11	-01(01)03	00(03)18	-01(04)25	-01(02)20	-01(03)07	-01(04)19	00(04)07	00(03)15	00(04)16	03(02)11
50	-01(06)23	04(08)09	00(02)03	-03(15)17	-01(04)25	-02(03)21	-02(03)06	-03(04)19	-01(04)06	-02(02)14	-02(03)15	-01(03)10
NATAL												
25	-02(03)03	-05(--)01			03(--)01	06(01)03	02(02)05	05(--)01	-01(02)03	01(07)04	03(--)01	
30	-02(01)03	-03(--)01			-03(06)02	05(02)02	-02(04)05	-04(02)03	-01(05)03	-02(02)09	-01(--)01	
35	-06(01)03				-08(04)03	-02(05)03	-01(05)05	-06(01)02	-04(02)03	-07(01)03	03(--)01	
40	-06(01)03				-04(02)03	03(02)03	-02(03)05	-07(03)03	-06(03)03	-07(02)06	02(--)01	
45	-05(03)03				-04(02)02	04(01)02	-02(03)04	-06(04)03	-08(02)03	-05(04)08	10(--)01	
50	-06(04)03				-05(01)02	03(06)02	-06(04)04	-08(02)03	-11(02)03	-08(02)06	07(--)01	
55	-07(03)03				-07(03)02		-10(01)03	-09(00)02	-10(02)03	-07(04)04		
ASCENSION ISLAND												
25	00(02)13	01(04)25	00(04)27	02(03)47	02(02)16	01(02)15	03(02)16	01(02)16	00(01)13	00(02)22	-01(02)23	00(02)25
30	-01(03)13	-01(03)25	03(06)27	02(03)46	02(03)16	03(04)15	02(05)16	00(04)16	01(03)13	04(04)22	04(03)23	03(05)25
35	-03(03)13	-02(07)25	00(04)26	00(05)40	-01(04)16	01(05)15	00(05)16	-03(04)16	-02(04)13	00(04)22	-03(04)23	-02(05)24
40	03(06)13	00(05)25	04(06)26	02(05)46	02(04)16	02(04)15	00(02)14	-03(05)16	-02(04)13	00(03)22	00(05)23	02(05)24
45	07(03)13	07(06)22	05(06)26	-01(05)46	02(05)16	06(05)14	04(05)14	-01(06)16	01(04)13	01(05)22	02(04)22	04(06)25
50	06(06)13	05(06)20	02(06)25	03(04)45	03(04)16	04(06)14	03(04)13	-04(07)16	03(07)13	02(03)21	01(04)21	03(05)25
55		-08(02)02	-07(--)01	-05(06)02		-06(08)02		-04(--)01	-06(--)01			
ANTIGUA												
25	02(02)13	01(04)19	-02(06)16	01(02)16	01(02)13	01(02)08	02(02)09	03(03)11	03(03)09	01(03)11	02(03)17	00(02)08
30	06(03)13	-01(05)20	00(05)16	01(04)16	02(03)13	03(04)08	01(04)07	01(04)11	00(02)09	0[illegible](04)11	02(04)17	07(04)08
35	01(04)07	-05(05)20	-04(06)16	00(04)15	00(04)13	-01(04)08	-01(05)08	-01(03)11	03(05)09	02(05)11	-01(03)17	02(04)07
40	03(02)06	-02(06)20	-02(06)15	02(03)13	00(04)11	01(03)08	01(04)08	01(06)11	01(03)09	04(04)10	02(05)17	05(05)07
45	01(03)06	02(05)16	-03(06)15	01(03)12	00(05)11	03(03)08	01(05)08	-02(05)10	03(04)09	04(02)07	02(05)16	02(06)07
50	-01(03)06	03(06)14	01(06)14	03(02)09	01(05)09	02(04)07	01(05)08	01(04)06	04(04)05	02(03)07	03(06)15	04(07)05
GRAND TURK												
25	01(02)16	01(03)17	00(03)16	-01(02)19	00(02)10	01(02)11	01(01)12	01(03)09	00(01)09	01(05)17	00(02)18	01(02)15
30	01(03)16	01(05)17	00(04)16	00(03)19	01(03)10	01(03)11	00(02)12	02(03)09	04(05)09	01(04)17	00(05)17	00(03)15
35	00(06)16	-04(05)17	01(05)16	01(04)19	00(03)09	00(04)10	00(03)11	-01(03)09	01(03)09	00(03)17	01(04)17	02(04)14
40	00(05)15	02(08)17	00(03)16	01(07)18	00(03)10	03(07)10	-02(04)11	-01(06)08	01(05)09	01(03)17	01(04)17	00(05)14
45	00(04)16	00(03)16	01(05)16	00(04)17	00(03)09	02(04)10	04(04)11	02(05)06	03(07)09	02(03)17	01(06)17	-01(05)13
50	-01(05)15	02(05)14	03(05)15	01(03)16	01(03)09	04(04)06	01(06)09	-01(01)04	01(04)06	02(04)16	02(04)17	00(04)11

* DATA USED FOR DEVELOPMENT OF TEMPERATURE MODEL AS LAUNCH SITE LIES WITHIN 70-160 DEG W LONGITUDE
DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 19. Mean Deviations of Observed Temperatures (°K) (Contd.)

ALT	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
BARKING SANDS*												
25	-04(00)02	-04(02)04	-02(04)05	01(05)03	-02(03)06	-02(03)08	-02(04)03	-01(01)04	02(02)03	-02(--)01	-02(03)05	-02(04)04
30	-04(03)02	-04(08)04	02(03)05	04(02)03	-02(02)07	-02(03)08	-01(05)05	-04(01)04	00(03)03	-02(--)01	-01(06)04	-03(04)04
35	-06(03)02	-05(12)04	04(04)05	04(06)03	-03(04)07	-01(05)08	-04(09)06	-06(01)04	-01(02)03	-05(--)01	01(09)05	05(12)04
40	-03(02)02	-04(12)04	04(05)05	02(10)03	-03(02)06	02(05)08	-03(03)06	-03(05)04	01(02)03	-03(--)01	04(08)04	-01(05)04
45	-05(03)02	-07(09)04	-05(06)05	02(05)03	00(03)06	02(09)08	02(05)06	-01(08)04	08(03)03	-02(--)01	13(05)04	-01(09)03
50	-06(01)02	-03(02)03	-03(05)06	01(--)01	-02(05)05	-06(07)07	04(04)05	01(07)04	07(03)03	00(--)01	19(01)02	02(03)02
55							05(25)03					
CAPE KENNEDY*												
25	04(03)07	01(02)26	01(02)16	03(02)20	01(02)15	00(02)19	-01(01)08	00(04)09	00(--)01	02(03)10	03(02)10	04(03)16
30	04(03)07	04(05)26	00(03)16	02(04)23	02(03)14	01(04)19	01(03)08	02(06)08	-03(--)01	05(06)10	02(03)13	07(04)16
35	01(06)07	-02(04)23	01(04)14	02(04)20	-01(02)13	00(04)19	-02(02)07	-01(07)08	00(--)01	02(03)13	10(05)08	-03(03)17
40	01(05)07	01(04)21	05(08)15	00(04)19	-02(03)13	-01(03)18	01(05)08	03(05)04	00(--)01	02(03)09	02(04)04	-06(05)17
45	00(08)07	06(05)21	03(04)16	-02(03)19	-02(03)13	-02(04)16	-04(03)08	-05(07)09	-03(--)01	04(03)07	02(04)07	-03(07)11
50	-01(07)07	00(07)17	-01(05)16	-02(04)14	-03(02)12	-03(04)15	-06(03)06	02(10)08	02(--)01	03(02)05	01(06)06	-04(07)11
[illegible]												
25		04(04)02	01(02)05	01(01)05	03(02)06	03(01)02	07(03)07	06(02)03	04(02)02	00(02)07	-01(03)04	-02(03)07
30		06(06)02	02(01)05	03(02)05	05(03)07	-06(00)02	01(05)06	03(03)03	03(02)02	-03(03)07	-04(03)04	-02(03)07
35		18(--)01	03(--)01	-01(01)03	03(01)05	-07(05)02	-05(04)04		03(--)01	-07(01)06	-07(--)01	-02(04)[illegible]
40		23(--)01	00(--)01	00(--)01	-10(07)04	-18(--)01	-16(00)02		00(--)01	-10(03)05	-07(--)01	02(02)03
45		21(--)01	04(05)04	-05(04)03	-07(04)05	-16(--)01	-06(07)06	-05(--)01	-01(--)01	-06(06)06	-01(11)08	04(04)06
50		15(12)02	06(03)04	-08(04)04	-04(05)06	-10(--)01	-01(06)06	-06(--)01	-03(--)01	-01(09)06	02(11)10	05(07)06
55		37(17)02	00(10)05	-05(06)05	-07(07)06	06(--)01	02(06)07	-12(--)01		00(09)06	-03(06)02	-01(07)06
WHITE SANDS*												
25		-03(03)05	-01(04)04	03(06)03	03(02)04	-02(03)11	00(03)09	01(06)04	02(06)02	01(03)05	-01(02)07	00(05)15
30		-06(03)05	-05(04)04	07(02)03	03(04)04	00(04)10	01(04)09	00(06)06	02(02)02	-02(02)05	-02(04)07	-01(06)15
35		-04(07)05	-06(04)04	04(05)03	00(06)04	-01(05)10	00(06)04	01(04)06	-01(06)02	-03(03)05	-05(04)07	-06(06)15
40		-06(08)05	-01(04)03	02(07)03	-01(07)04	02(04)10	-01(05)09	04(05)06	-01(02)02	-02(06)05	-01(07)04	-03(05)15
45		-03(03)04	01(01)03	00(09)03	02(06)04	-01(05)10	01(06)04	01(03)06	05(--)01	00(05)05	00(06)04	02(09)15
50		-07(01)03	-04(04)03	04(07)03	04(10)04	00(06)10	05(06)09	03(04)06	03(--)01	-02(03)05	-01(04)07	01(07)15
55			06(--)01					05(02)03			04(02)02	
POINT MUGU*												
25	-01(04)04	00(02)04	-01(03)08	02(06)07	00(04)05	-01(02)09	03(04)04	03(01)03	-02(03)04		-01(01)02	03(05)04
30	-01(05)04	01(04)04	-03(04)07	06(06)07	-01(05)05	03(04)09	04(06)04	01(05)03	00(04)04		-01(01)02	01(06)08
35	-05(10)04	-02(06)04	06(09)07	00(05)07	-06(04)05	03(04)09	05(06)04	06(04)03	-01(08)04		-01(04)02	-03(07)08
40	-06(04)04	-03(06)04	07(05)07	-07(11)06	-07(05)05	03(03)09	05(11)04	00(04)03	-01(10)04		-03(05)02	-03(06)08
45	04(15)03	04(03)04	08(03)08	-02(03)06	-04(08)05	-01(03)09	06(09)04	09(06)03	06(11)04		06(09)02	04(14)05
50	00(09)07	01(09)03	04(03)08	-02(04)05	-02(10)05	02(05)08	09(12)04	13(09)03	06(13)04		10(03)02	08(05)04

* DATA USED FOR DEVELOPMENT OF TEMPERATURE MODEL AS LAUNCH SITE LIES WITHIN 70-160 DEG W LONGITUDE
DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 19. Mean Deviations of Observed Temperatures (°K) (Contd.)

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
WALLOPS ISLAND*												
25	06(09)02	-03(03)08	00(04)08	02(04)08	-05(06)09	05(--)01	01(04)04	-02(04)08	00(02)08	04(02)02	03(03)15	-01(05)10
30	05(17)02	01(04)16	04(05)11	03(06)11	-02(08)12	00(03)02	01(03)06	-02(05)12	-01(04)09	02(01)06	03(03)16	-02(06)13
35	06(16)02	05(09)21	07(07)11	03(07)11	-02(09)12	00(05)03	00(04)06	-02(05)17	-04(06)08	01(01)07	00(05)20	00(07)14
40	06(09)02	02(11)21	03(08)10	-02(06)10	01(10)12	-07(03)03	00(09)06	-01(03)15	-05(04)08	05(05)07	02(06)20	-02(07)14
45	12(04)02	-02(07)18	02(09)10	-15(31)10	00(11)09	-03(05)03	-01(08)06	-01(06)14	-03(09)06	01(04)07	-01(09)18	-03(09)13
50	11(--)01	-03(12)16	03(09)10	-09(04)06	-05(10)08	-05(03)03	01(07)04	-04(10)17	-10(07)04	-01(13)06	-03(09)15	-03(08)10
55		02(20)16	-13(18)06	-02(08)03	-04(05)06	-03(03)02	00(10)03	-02(10)10	-04(04)04	00(03)05	-08(09)07	-07(08)04
WEST GEIRINISH												
25	-06(15)14	-12(09)19	-11(06)17	-07(03)18	-08(03)04					-01(03)05	-06(05)12	-14(06)05
30	04(16)14	-12(07)20	-14(07)19	-10(04)18	-05(02)04					-02(05)05	-09(05)12	-18(05)05
35	15(17)14	-10(12)20	-09(11)19	-12(05)19	-01(04)04					-01(04)05	-07(06)12	-09(06)06
40	15(25)14	-08(13)20	-04(08)19	-07(05)19	04(05)04					-03(04)05	-08(07)12	-02(08)06
45	09(20)14	-03(12)20	04(08)19	-04(04)19	01(03)04					-04(04)04	-01(07)12	06(18)06
50	-01(22)14	-05(10)20	02(06)19	-02(04)19	-01(03)04					00(03)04	-01(09)12	11(12)06
FORT CHURCHILL*												
25	02(08)23	00(08)25	-06(11)05	06(15)11	-01(05)19	-01(02)16	01(02)14	00(03)23	02(03)13	-02(03)14	00(07)21	02(08)29
30	02(05)22	01(11)33	-04(06)06	06(09)11	00(06)20	00(02)16	01(02)14	01(04)26	01(03)13	00(04)15	-01(05)22	00(07)30
35	02(09)22	02(13)35	-03(04)08	03(10)11	01(04)20	-02(03)16	01(02)14	-01(05)27	01(03)15	-01(06)14	-02(07)24	-01(08)27
40	00(13)21	03(14)37	-01(12)07	03(09)11	01(04)17	00(03)16	01(03)15	-01(05)31	01(04)16	01(07)14	-02(08)24	-01(09)31
45	00(16)21	03(14)36	-04(09)07	03(09)11	01(03)16	00(03)16	01(05)15	-01(05)32	02(04.16	01(05)13	-03(10)20	00(10)30
50	-02(15)23	04(15)33	-02(15)07	03(06)11	02(04)16	-01(02)14	01(06)14	00(05)32	01(04)13	05(08)10	-02(11)18	-01(09)26
55		03(16)15	-06(07)04		-03(00)03	-03(--)01	-06(--)01	-03(04)13	-01(03)03	-07(--)01	-02(07)04	-03(07)07
FORT GREELY*												
25	11(09)20	09(05)24	07(07)40	-01(06)43	-03(05)36	-01(02)27	00(03)12	-04(02)10	-03(04)09	-02(04)12	05(06)34	07(07)16
30	08(14)23	05(08)24	03(09)41	-02(06)43	-03(05)36	-01(03)27	00(04)12	-03(04)10	-05(04)09	-01(03)12	04(09)34	05(03)16
35	06(16)18	07(10)24	00(11)39	-03(06)43	00(06)33	00(02)26	00(05)12	-05(04)10	-04(06)09	00(06)12	04(10)33	05(08)16
40	07(17)16	03(13)24	-04(11)38	-03(07)41	01(06)29	-01(03)26	-01(05)12	-01(10)10	00(07)08	02(08)12	04(15)29	03(13)15
45	10(18)16	-02(14)23	-04(10)33	-01(09)33	02(07)25	-02(04)26	-01(03)11	-01(08.09	02(07)07	05(05)10	02(12)23	06(14)12
50	11(13)14	01(12)20	-01(08)29	01(07)33	01(06)23	-01(03)25	-01(03)11	01(04)08	03(08)06	08(08)05	01(08)18	02(08)07
POINT BARROW*												
25		12(--)01						-04(07)05				
30		21(01)03					-01(--)01	01(11)09		-08(--)01	-03(--)01	
35		14(06)06			12(11)02	01(--)01	01(--)01	04(10)10		-05(--)01	12(11)03	
40		16(09)06			04(07)02	02(--)01	-01(--)01	00(05)08		-10(--)01	09(01)03	
45		09(10)06			00(02)02	03(--)01	02(--)01	-04(06)07		-08(--)01	-12(31)03	
50		-01(10)06			-03(02)02	-02(--)01	00(--)01	-02(01)06		-18(--)01	-08(07)03	
55		-10(07)06			-02(06)02	00(--)01	03(--)01	02(03)06		-17(--)01	-06(07)03	

* DATA USED FOR DEVELOPMENT OF TEMPERATURE MODEL AS LAUNCH SITE LIES WITHIN 70-150 DEG W LONGITUDE
DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH

Table 20. Mean Deviations and Standard Deviations (in brackets) of Monthly MRN Mean Temperatures (1965 to 1968) From the Model at 25 to 50 km. The last digit gives the number of years for which means are available

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
ASCENSION ISLAND												
25	-01(00)2	00(00)2	00(01)2	01(01)2	02(01)2	03(02)2	04(01)2	03(03)2	00(04)2	00(03)2	01(00)2	02(03)2
30	00(04)2	01(04)2	03(02)2	02(04)2	01(03)2	02(04)2	03(03)2	02(03)2	00(02)2	02(03)2	04(03)2	00(01)2
35	-03(04)2	00(04)2	00(02)2	00(01)2	01(01)2	01(00)2	00(01)2	-02(01)2	-02(02)2	-03(03)2	-03(04)2	-04(04)2
40	02(02)2	04(03)2	04(01)2	03(01)2	01(01)2	-01(01)2	-03(00)2	-04(01)2	-02(01)2	-02(01)2	00(03)2	-03(03)2
45	04(01)2	07(00)2	03(00)2	00(01)2	00(00)2	01(01)2	01(02)2	-01(04)2	-04(01)2	-02(00)2	02(00)2	02(01)2
50	-01(04)2	01(01)2	00(01)2	-02(00)2	-02(01)2	-01(04)2	-04(01)2	-05(00)2	-03(03)2	-03(00)2	-03(03)2	-04(01)2
CAPE KENNEDY*												
25	01(01)4	02(02)4	02(02)4	01(01)4	00(00)4	00(00)4	01(00)4	00(01)4	-01(00)4	00(01)4	02(02)4	00(02)4
30	02(02)4	02(02)4	02(01)4	01(00)4	01(01)4	00(01)4	01(00)4	01(01)4	02(01)4	01(02)4	01(02)4	01(03)4
35	01(03)4	01(02)4	02(02)4	00(02)4	-02(01)4	00(01)4	00(01)4	00(02)4	00(01)4	-01(01)4	00(05)4	02(03)4
40	01(03)4	00(02)4	00(03)4	-02(03)4	-01(01)4	00(01)4	00(02)4	00(02)4	00(01)4	-01(01)4	00(06)4	-01(01)4
45	03(03)4	01(05)4	00(02)4	-03(01)4	-03(00)4	-02(02)4	-02(01)4	-02(01)4	01(01)4	00(02)4	-01(07)4	02(02)4
50	-03(02)4	-04(05)4	00(01)4	-02(01)4	-03(01)4	-02(01)4	-03(02)4	-02(01)4	00(01)4	-01(01)4	-01(03)4	02(03)4
WHITE SANDS*												
25	-02(02)4	-01(02)4	00(01)4	00(02)4	-01(02)3	-01(02)4	00(02)4	-01(01)4	00(02)4	00(02)4	-01(01)4	-01(01)4
30	-03(03)4	-02(03)4	01(02)4	01(03)4	01(04)4	01(01)4	00(02)4	01(02)4	00(02)4	00(03)4	-02(02)4	-03(01)4
35	-03(05)4	01(07)4	00(03)4	-02(03)4	-01(04)4	00(02)4	-01(01)4	00(03)4	-01(01)4	-02(02)4	-04(02)4	00(01)4
40	-03(05)4	-01(04)4	-02(04)4	-02(03)4	00(03)4	01(01)4	00(02)4	-02(01)4	-02(02)4	-02(01)4	-06(04)4	03(02)4
45	-02(01)4	-01(03)4	-04(02)4	-02(03)4	-01(03)4	01(00)4	01(02)4	-02(03)4	-02(02)4	-02(02)4	-06(02)4	01(08)4
50	-03(03)4	-03(03)4	-04(01)4	-01(03)3	-01(03)4	-01(02)4	-01(01)4	-03(02)4	-02(03)4	-02(02)4	-06(03)4	-04(05)4
POINT MUGU*												
25	-01(03)4	-01(01)4	00(01)4	-01(02)4	-01(01)4	-01(01)4	00(01)4	00(01)4	00(01)4	00(01)4	-01(02)4	-02(02)4
30	-02(03)4	-01(04)4	02(02)4	01(03)4	00(01)4	02(01)4	01(02)4	02(01)4	01(03)4	01(02)4	00(02)4	-03(02)4
35	-03(02)4	02(02)4	03(02)4	-02(02)4	-01(02)4	00(01)4	00(01)4	01(01)4	01(01)4	01(02)4	00(02)4	-01(03)4
40	-02(05)4	00(02)4	-02(03)4	-03(03)4	-02(00)4	01(01)4	00(01)4	-01(01)4	01(01)4	00(02)4	-05(03)4	03(02)4
45	-01(04)4	-02(06)4	-01(03)4	-04(03)4	-03(01)4	-01(02)4	-01(02)4	00(01)4	01(01)4	-01(01)4	-05(01)4	03(05)4
50	-02(02)4	-02(01)4	-01(03)4	-05(01)4	-02(03)4	-01(03)4	-01(01)4	-02(01)4	00(01)4	00(02)4	-03(01)4	02(03)4
WALLOPS ISLAND*												
25	-01(03)3	01(01)2	00(01)3	-03(02)4	00(02)4	00(01)4	00(02)4	00(00)4	00(01)4	01(01)4	01(03)4	-02(02)3
30	-02(02)4	01(01)2	01(03)4	-02(01)4	-01(00)4	01(01)4	00(01)4	00(01)4	02(01)4	02(02)4	-01(03)4	00(06)3
35	02(07)4	-01(03)2	00(02)4	-03(04)4	00(03)4	01(01)4	00(02)4	00(00)4	00(01)4	01(02)4	-02(03)4	04(07)3
40	01(06)4	00(01)2	01(04)4	-02(01)4	-03(03)4	01(01)4	-02(02)4	-02(02)4	00(00)4	01(01)4	-04(05)4	01(05)4
45	02(05)4	-01(08)2	-01(04)4	-02(01)4	00(03)4	00(02)4	-01(01)3	03(03)4	00(01)4	01(03)4	-03(04)4	04(07)4
50	04(06)2	00(01)2	-01(03)3	-01(05)4	-01(02)4	01(02)3	01(02)3	00(01)4	01(01)3	01(04)4	01(04)4	05(06)3
FORT GREELY*												
25	06(05)4	06(08)4	00(04)4	-01(03)4	00(01)4	00(01)4	00(03)4	00(04)3	00(05)4	02(03)4	06(06)4	09(05)4
30	08(07)4	06(11)4	-01(06)4	-01(01)4	01(02)4	00(02)4	00(04)4	02(06)3	-01(05)4	00(04)4	05(08)4	07(07)4
35	05(09)4	05(12)4	00(04)4	-02(01)4	01(03)4	00(02)4	-01(05)4	00(06)3	-01(03)4	00(04)4	04(07)4	00(08)4
40	00(09)4	03(14)4	02(10)4	-02(01)4	-01(04)4	-01(02)4	00(05)4	00(06)3	-01(01)4	-01(04)4	01(05)4	-02(08)4
45	-02(08)4	-03(14)4	00(07)4	-02(02)4	-01(02)4	00(00)4	01(04)4	00(03)3	-01(01)4	-01(01)4	-01(06)4	02(03)4
50	00(06)4	-02(05)4	04(06)4	00(01)4	00(02)4	01(02)4	00(01)4	02(02)3	00(03)4	-01(02)4	02(08)4	04(08)4

* DATA USED FOR DEVELOPMENT OF TEMPERATURE MODEL AS LAUNCH SITE LIES WITHIN 70-160 DEG W LONGITUDE

Table 21. Mean Deviations of Observed Temperatures (^{o}K) From the Model Followed by Standard Deviations (in brackets) and the Number of Observations at 60 to 110 km

KM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
NATAL(22), ASCENSION ISLAND(9), KWAJALEIN(17), GUAM(5)												
60	-09(10)04	00(09)04	01(09)05	-02(05)08	02(--)01	05(01)02	01(07)04	03(08)02	-02(03)02	-11(13)02	-04(06)05	-04(06)07
65	-05(12)04	01(07)04	01(03)05	00(06)08	-12(--)01	06(02)02	01(09)03	-01(05)02	06(03)02	00(01)02	-05(05)06	05(07)06
70	00(07)04	-05(04)04	01(04)05	-03(05)09	-23(--)01	05(01)02	-01(18)03	30(--)01	08(13)02	05(08)02	-18(07)05	07(05)05
75	07(11)03	01(07)03	-03(04)05	-02(11)09	-13(--)01	02(00)02	-05(16)04	15(--)01	01(09)02	-03(10)02	04(13)05	-04(04)03
80	00(20)03	03(04)03	-05(07)04	-03(09)09	-14(--)01		-07(12)05	12(--)01	23(--)01	-04(08)02	01(07)05	07(04)02
85	01(07)03	-03(02)03	01(06)04	01(17)04	18(--)01		05(03)05	23(--)01	21(--)01	-02(08)02	07(15)05	04(07)02
90	-12(23)03	04(10)03	-05(26)04	-02(21)09	-32(--)01		-11(13)08	35(--)01	24(--)01	09(32)02	-12(11)03	12(08)02
95		-55(--)01	-52(--)01	-24(--)01	-12(--)01		-07(36)05	44(--)01	23(--)01	07(61)02	-37(11)03	01(11)12
100			-44(--)01	-05(--)01	-22(--)01		02(30)04	44(--)01		-45(--)01	-02(31)02	-17(--)01
105			-24(--)01	-31(--)01	-05(--)01		-09(18)05	38(--)01			-03(--)01	-44(--)01
110			-12(--)01	14(--)01	-43(--)01		02(33)05				-31(15)02	
BARKING SANDS(5), CARNARVON(11), EGLIN(12), WOOMERA(52), WSMR(13), WALLOPS(66)												
60	03(10)04	-01(10)22	-02(08)11	01(04)10	03(10)12	-04(08)07	03(09)06	-01(12)10	03(12)09	06(07)13	-01(09)24	04(12)05
65	09(13)04	01(10)22	-02(11)11	01(05)10	04(10)12	04(08)07	-10(12)05	07(09)15	10(12)04	05(08)04	03(08)24	02(08)05
70	-07(13)03	01(15)22	00(12)11	01(07)11	02(11)11	03(07)06	-07(09)06	03(09)15	-02(08)09	01(08)13	05(07)27	[illegible]
75	-05(05)03	06(18)21	06(15)11	01(05)10	01(05)11	08(14)06	-05(14)06	07(11)15	00(07)04	-03(08)11	07(12)25	[illegible]
80	-03(09)07	06(23)16	-03(09)10	07(06)06	-02(10)11	02(05)06	08(17)06	05(13)12	02(09)07	-03(08)11	32(09)25	-13(13)25
85	-05(04)04	08(21)11	-05(08)07	07(09)06	-02(05)10	03(18)03	-10(11)03	06(04)11	07(15)05	03(10)04	-08(11)21	12(09)15
90	-11(08)02	05(11)07	-04(08)06	05(04)03	04(13)04	05(21)03	07(13)02	-08(04)04	33(25)05	-09(21)05	-31(15)15	[illegible]
95		65(09)03	-05(12)07	04(--)01	05(--)01		20(24)02	-15(12)04	11(08)02		01(20)05	
100		06(26)03	-02(20)06	12(--)01	12(--)01		-07(05)02	-21(15)04	05(14)02		-05(19)05	
105		15(13)02	-01(17)06	12(--)01	13(--)01		52(14)02	-13(23)03	-21(--)01		36(37)02	
110			-04(12)05	02(--)01	-02(--)01		-23(37)02	-23(18)03	-29(--)01		-16(12)02	
SARDINIA(2), ST SANTIN(25), VOLGOGRAD(18), FT CHURCHILL(53), PT BARROW(19)												
60	-15(--)01	-01(10)21	02(09)05	-06(--)01	01(03)06	03(01)03	01(04)04	03(06)20	-02(04)06	-03(10)05	03(15)11	-01(04)07
65	-14(--)01	00(10)21	01(10)05	-14(--)01	-03(08)06	-01(07)03	04(11)04	-01(07)20	-02(14)05	-02(06)05	-03(16)13	02(12)04
70	-16(--)01	00(10)21	00(15)04	-30(--)01	-01(10)08	-03(08)03	02(10)04	00(06)20	-04(08)05	03(07)05	-05(17)13	04(20)08
75		01(20)17	-02(18)04	-33(--)01	-01(11)08	-09(12)03	-32(06)03	00(09)20	-03(04)04	-03(08)04	02(17)04	02(12)08
80		05(24)16	-04(17)03	-36(--)01	-04(14)06	-02(04)03	03(13)02	05(17)20	-02(05)04	02(07)04	02(18)07	-01(11)07
85		00(14)14	-02(06)02		07(05)04	04(17)02	-03(--)01	-03(11)15	-02(13)02	05(16)04	-05(20)04	01(06)06
90		04(12)06			-02(04)02	-17(02)02	25(--)01	-04(12)10		00(06)03	03(--)01	01(10)03
95		-11(--)01			-14(--)01	-46(--)01		17(33)02		-01(11)02	01(--)01	06(19)03
100		-01(--)01	02(--)01	08(--)01	13(--)01	-04(21)02	05(05)02	00(13)02	04(06)02	-22(--)01	00(16)02	10(13)02
105				04(--)01	13(--)01	-05(14)02	09(17)02	-05(11)02	-12(12)02		26(--)01	
110	-07(--)01	-13(--)01	-22(--)01	-25(13)03	-15(12)02	-08(15)02	09(11)03	-15(13)02	-13(--)01	32(22)03	-07(14)02	-02(--)01

DATA ARE GROUPED FROM THE MIDDLE OF THE STATED MONTH TO THE MIDDLE OF THE PREVIOUS MONTH
THE NUMBER OF PROFILES FROM EACH SITE IS SHOWN IN BRACKETS AFTER THE NAME OF THE SITE

Table 22. Temperatures (°K) at 80°N Based on 20-50 km Data at Thule (207 profiles) and on 20-80 km Data at Heiss Island (33 profiles)

km	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
25	204	200	198	211	238	239	239	239	229	213	201	206
30	205	200	210	222	248	246	248	247	237	216	207	208
35	209	199	226	239	254	258	259	259	248	225	215	215
40	214	205	245	255	264	269	269	270	260	237	224	220
45	223	219	254	275	270	281	283	285	272	253	239	234
50	249	250	269	281	279	286	293	289	278	261	253	255
55	254	248	254	264	273	280	283	276	263	250	255	258
60	244	234	232	244	262	267	267	260	245	231	236	247
65	228	212	211	227	242	247	244	240	229	214	226	238
70	200	195	198	209	223	220	214	212	204	198	210	206
75	194	193	194	202	207	204	196	197	191	200	196	198
80	211	210	212	207	196	185	182	192	211	223	222	219

Table 23. Stations Selected for the Construction of the 30 km Pressure Model

Station	Latitude	Longitude
Mould Bay	76° 14'N	119° 20'W
Sachs Harbour	72° 00'N	124° 30'W
Coppermine	67° 47'N	115° 15'W
Fort Smith	60° 01'N	111° 58'W
Edmonton	53° 34'N	113° 31'W
Spokane	47° 37'N	117° 31'W
Salem	44° 55'N	123° 01'W
Grand Junction	39° 07'N	108° 32'W
San Diego	32° 49'N	117° 08'W
Brownsville	25° 54'N	97° 26'W
Merida	20° 58'N	89° 31'W
Swan Island	17° 24'N	83° 56'W

Table 24a. Pressures (N/m^2) 25 to 110 km. Insert decimal point on the right of the three digits and multiply by 10^N

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70	N
JANUARY 1									
25	250	247	244	239	237	241	244	240	1
30	118	117	114	112	111	112	111	105	1
35	582	576	562	546	529	527	509	472	0
40	299	295	286	275	261	254	237	216	0
45	157	155	152	146	136	127	116	103	0
50	842	832	816	778	720	659	587	515	-1
55	454	449	442	420	383	345	306	266	-1
60	241	237	232	217	198	177	155	134	-1
65	122	119	117	110	100	089	079	067	-1
70	577	561	549	519	481	435	382	317	-2
75	255	249	243	236	222	207	183	146	-2
80	110	108	105	102	100	095	084	067	-2
85	471	463	446	440	437*	429*	384	305	-3
90	197	194	187*	184*	190*	191*	174	138	-3
95	803	791*	767*	778*	833*	873*	813*	646*	-4
100	350	345*	338*	345*	379*	401*	376*	301*	-4
105	168	164*	160*	163*	177*	190*	181*	145*	-4
110	898	889*	856*	843*	899*	939*	887*	701*	-5
FEBRUARY 1									
25	250	246	242	239	239	243	241	231	1
30	118	116	114	112	111	112	111	105	1
35	581	572	560	543	531	523	5[illegible]7	485	0
40	298	293	286	274	264	255	246	227	0
45	157	156	152	144	137	130	122	110	0
50	848	839	820	773	734	683	625	546	-1
55	458	455	443	413	390	359	325	279	-1
60	243	238	231	215	202	185	165	140	-1
65	122	119	114	106	100	092	083	069	-1
70	577	551	534	504	482	450	397	321	-2
75	256	245	240	229	223	211	188	147	-2
80	111	106	105	102	101	097	086	066	-2
85	469	448*	451	439	440	434	393	295	-3
90	200	188*	188	187	191	192	175	133	-3
95	855*	832*	797	784	814	843*	792*	630*	-4
100	395*	364*	362	357	366	377*	359*	278*	-4
105	199*	182*	178*	171*	174*	179*	174*	135*	-4
110	113*	101*	096*	091*	091*	093*	090*	071*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W

(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24a. Pressures (N/m^2) 25 to 110 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70	N
MARCH 1									
25	251	246	244	240	240	243	238	225	1
30	118	117	115	113	112	112	110	105	1
35	582	575	566	552	533	529	521	501	0
40	299	297	290	279	267	262	255	242	0
45	159	158	154	146	139	135	130	121	0
50	860	859	833	781	741	718	675	616	-1
55	465	461	446	416	392	380	354	319	-1
60	244	241	231	214	203	196	181	162	-1
65	121	117	113	106	101	098	090	079	-1
70	569	547	528	503	487	475	434	372	-2
75	255	240	237	231	225	223	205	171*	-2
80	110	105	105	103	102	102	094	076*	-2
85	476	444	450	446	438	444	420	339*	-3
90	206	191	191	188	187	191*	182*	146*	-3
95	903*	811	802	789	785	804*	783*	645*	-4
100	419*	374*	362	354	354	365*	355*	298*	-4
105	213*	183*	175*	169	167	174*	177*	153*	-4
110	122*	104*	096*	089	088	094*	098*	086*	-4
APRIL 1									
25	251	250	246	244	241	241	240	239	1
30	119	119	117	116	114	114	113	111	1
35	590	588	583	570	554	553	545	522	0
40	305	306	300	291	282	282	273	254	0
45	163	162	159	153	148	149	142	130	0
50	886	883	861	825	801	804	761	686	-1
55	478	473	462	439	427	430	407	363	-1
60	250	247	240	229	223	225	210*	188*	-1
65	123	121	119	114	111	112	106*	093*	-1
70	575	568	565	551	539	546	511*	448*	-2
75	253	250	257	253	250	253	240*	209*	-2
80	110	109	113	114	112	114	108*	093*	-2
85	479	471	494	493	478	475*	458*	392*	-3
90	212	206	213	212	198	192*	184*	158*	-3
95	920*	880	900*	873*	813	769*	754*	658*	-4
100	416*	386*	386*	380*	359	348*	341*	305*	-4
105	202*	182*	178*	172*	165	167*	176*	154*	-4
110	112*	098*	093*	089*	086	092*	102*	099*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24a. Pressures (N/m^2) 25 to 110 km (Contd.)

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	N
MAY 1									
25	251	254	250	249	247	246	249	254	1
30	120	120	120	118	117	117	118	120	1
35	595	598	595	584	576	577	581	586	0
40	309	311	307	299	298	300	299	292	0
45	164	165	163	159	158	160	159	155	0
50	889	896	882	859	861	880	869	832	-1
55	480	481	475	463	464	474	470	456	-1
60	253	254	248	242	244	250	248	239*	-1
65	126	127	125	122	122	126	125*	123*	-1
70	582	597	600	587	591	607	608*	596*	-2
75	254	263	271	268	267	276	280*	283*	-2
80	111	115	118	115	115	118	121*	121*	-2
85	489	496	505	485	464	459	472*	477*	-3
90	213	214	215	199	181	169*	170*	170*	-3
95	887*	899*	901*	819	700	619*	622*	649*	-4
100	379*	379*	382*	351*	308	276*	280*	292*	-4
105	172*	172*	175*	163*	145	135*	145*	162*	-4
110	091*	088*	089*	084*	078	079*	089*	100*	-4
JUNE 1									
25	251	253	253	253	256	258	260	255	1
30	119	120	121	121	122	123	125	128	1
35	592	597	597	599	602	611	627	642	0
40	306	308	306	308	311	318	326	330	0
45	161	163	162	163	166	171	176	178	0
50	869	881	878	886	905	935	965	974	-1
55	468	474	474	477	487	508	528	537	-1
60	248	251	249	251	258	271	282	288*	-1
65	125	127	126	125	128	137	144	150*	-1
70	585	599	592	593	607	652	695*	731*	-2
75	255	265	264	262	265	286	313*	335*	-2
80	112	114	114	111	110	117	128*	136*	-2
85	486	487	479	456	423	423	453*	483*	-3
90	208	206	201	183	156	141	145*	152*	-3
95	853*	852	833	737*	577	480	489*	526*	-4
100	360*	362*	361*	327*	260	214	216*	230*	-4
105	162*	164*	167*	156*	127	108	112*	124*	-4
110	840*	837*	867*	836*	719	640	689*	771*	-5

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24a. Pressures (N/m^2) 25 to 110 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70	N
JULY 1									
25	250	252	256	259	263	265	269	274	1
30	118	119	122	123	125	128	130	133	1
35	582	591	600	605	622	640	653	662	0
40	299	301	305	309	318	331	340	345	0
45	157	158	161	163	169	177	184	185	0
50	084	085	087	088	091	096	101	102	0
55	454	457	466	470	492	521	551	564	-1
60	241	242	245	246	257	275	295	307	-1
65	122	123	123	122	128	139	152	159	-1
70	577	578	573	562	595	654	730	779	-2
75	255	256	253	245	257	284	322	348	-2
80	110	110	109	104	104	111	126	137	-2
85	471	471	460	423	395	393	425	452*	-3
90	197	198	191	170	145	131	131	135*	-3
95	803	812	793	688	569	479	458*	456*	-4
100	350	357	354	317	262	218	198*	191*	-4
105	168	170	168	153	132	110	101*	098*	-4
110	898	903	895	835	725	626	576*	559*	-5
AUGUST 1									
25	250	253	257	260	264	265	270	276	1
30	118	120	122	123	126	128	130	132	1
35	581	592	595	606	623	640	648	650	0
40	298	301	303	307	319	330	335	332	0
45	157	158	158	161	169	175	178	177	0
50	848	844	852	863	907	946	971	963	-1
55	458	457	454	462	485	509	526	525	-1
60	243	240	240	241	252	266	280	291	-1
65	122	123	121	120	124	132	141	145	-1
70	577	584	579	563	571	615	676	709	-2
75	256	268	261	251	250	268	295	316	-2
80	111	116	116	109	104	106	115	125	-2
85	469	506	501	459	408	390	397	430	-3
90	200	214	214	189	158	140	134	138	-3
95	855*	931	902	796	660	567	504	489*	-4
100	395*	421*	412*	359	301	255*	216*	199*	-4
105	199*	213*	199*	171	145*	122*	102*	091*	-4
110	113*	117*	109*	090	075*	063*	052*	045*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24a. Pressures (N/m^2) 25 to 110 km (Contd.)

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	N
SEPTEMBER 1									
25	251	253	254	257	259	260	260	252	1
30	118	120	121	122	124	124	124	124	1
35	582	589	596	597	607	613	610	599	0
40	299	301	303	302	307	313	310	301	0
45	159	159	160	158	162	165	163	157	0
50	860	858	858	845	865	883	875	840	-1
55	465	464	461	451	461	471	467	450	-1
60	244	245	242	234	235	241	243	237	-1
65	121	124	125	118	115	117	121	120	-1
70	565	600	606	560	528	537	573	582	-2
75	255	275	283	255	233	234	252	262	-2
80	110	122	126	112	098	096	103	110	-2
85	476	527	550	477	405	378	399	430*	-3
90	206	230	236	200	166	150	153	164*	-3
95	090*	101*	104*	087	072	063*	062*	064*	-3
100	419*	480*	487*	404	328	280*	265*	261*	-4
105	213*	246*	247*	199*	158*	131*	119*	110*	-4
110	122*	141*	138*	107*	082*	066*	056*	048*	-4
OCTOBER 1									
25	251	250	251	253	254	254	250	243	1
30	119	119	119	120	119	118	116	113	1
35	590	588	585	583	578	564	556	539	0
40	305	302	298	295	289	281	274	264	0
45	163	161	157	153	150	145	140	135	0
50	886	869	850	824	801	767	740	708	-1
55	478	468	457	439	426	403	389	374	-1
60	250	246	240	228	217	204	199	191	-1
65	123	123	122	113	106	099	099	095	-1
70	575	586	594	549	487	454	466	452	-2
75	253	265	274	248	217	202	213	207	-2
80	110	117	122	110	094	087	093	092	-2
85	479	515	533	471	402	371	398	400*	-3
90	212	228	233	202	172	158	169	170*	-3
95	092*	099*	102*	088	075	069	074	074*	-3
100	416*	462*	480*	413	343	310	325	316*	-4
105	202*	230*	242*	207*	172	151*	150*	139*	-4
110	112*	130*	137*	116*	093*	078*	072*	061*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24a. Pressures (N/m^2) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70	N
				LATITUDE (DEGREES N)					
NOVEMBER 1									
25	251	250	248	247	246	245	244	239	1
30	120	119	118	116	115	113	111	109	1
35	595	589	578	562	546	529	518	511	0
40	309	303	294	283	270	255	247	244	0
45	164	161	155	148	139	129	123	122	0
50	889	869	838	792	736	666	633	632	-1
55	480	470	452	425	388	346	330	333	-1
60	253	248	239	221	200	177	168	169	-1
65	126	124	120	110	098	087	084	084	-1
70	582	576	571	525	464	413	404	396	-2
75	254	255	256	237	210	191	190	184	-2
80	111	112	113	104	093	086	087	084	-2
85	489	495	492	448	402	381	393	387*	-3
90	213	216	212	192	175	169	178*	176*	-3
95	887*	899	888	826	774	772	819*	811*	-4
100	379*	395	405	384	365	364*	386*	372*	-4
105	172*	184*	195*	192*	183*	180*	184*	174*	-4
110	091*	100*	109*	106*	099*	093*	091*	081*	-4
DECEMBER 1									
25	251	247	245	241	239	241	242	240	1
30	119	118	116	113	111	112	110	107	1
35	592	584	565	552	530	524	506	486	0
40	306	301	289	279	263	252	237	227	0
45	161	159	152	147	136	125	116	110	0
50	869	854	827	788	723	645	586	563	-1
55	468	460	442	422	382	336	303	294	-1
60	248	243	234	221	198	172	154	150	-1
65	125	122	117	111	099	086	078	075	-1
70	585	566	556	533	477	420	381	357	-2
75	255	250	245	239	220	199	183	167	-2
80	112	109	108	105	099	091	085	077	-2
85	486	477	459	449	433	411	388	353	-3
90	208	204	199	194	191	185	179	162	-3
95	853*	833	807	822	849*	867*	841	764*	-4
100	360*	353	353*	368*	393*	412*	405	361*	-4
105	162*	161*	161*	173*	188*	201*	195*	172*	-4
110	840*	850*	872*	912*	962*	992*	947*	816*	-5

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W

(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24b. Pressures (N/m^2) 25 to 110 km. Insert decimal point on the right of the three digits and multiply by 10^N

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
0 DEGREES N													
25	250	250	251	251	251	251	250	250	251	251	251	251	1
30	118	118	118	119	120	119	118	118	118	119	120	119	1
35	582	581	582	590	595	592	582	581	582	590	595	592	0
40	299	298	299	305	309	306	299	298	299	305	309	306	0
45	157	157	159	163	164	161	157	157	159	163	164	161	0
50	842	848	860	886	889	869	842	848	860	886	889	869	-1
55	454	458	465	478	480	468	454	458	465	478	480	468	-1
60	241	243	244	250	253	248	241	243	244	250	253	248	-1
65	122	122	121	123	126	125	122	122	121	123	126	125	-1
70	577	577	569	575	582	585	577	577	569	575	582	585	-2
75	255	256	255	253	254	255	255	256	255	253	254	255	-2
80	110	111	110	110	111	112	110	111	110	110	111	112	-2
85	471	469	476	479	489	486	471	469	476	479	489	486	-3
90	197	200	206	212	213	208	197	200	206	212	213	208	-3
95	803	855*	903*	920*	887*	853*	803	855*	903*	920*	887*	853*	-4
100	350	395*	419*	416*	379*	360*	350	395*	419*	416*	379*	360*	-4
105	168	199*	213*	202*	172*	162*	168	199*	213*	202*	172*	162*	-4
110	090	113*	122*	112*	091*	084*	090	113*	122*	112*	091*	084*	-4
10 DEGREES N													
25	247	246	246	250	254	253	252	253	253	250	250	247	1
30	117	116	117	119	120	120	119	120	120	119	119	118	1
35	576	572	575	588	598	597	591	592	589	588	589	584	0
40	295	293	297	306	311	308	301	301	301	302	303	301	0
45	155	156	158	162	165	163	158	158	159	161	161	159	0
50	832	839	859	883	896	881	846	844	858	869	869	854	-1
55	449	455	461	473	481	474	457	457	464	468	470	460	-1
60	237	238	241	247	254	251	242	240	245	246	248	243	-1
65	119	119	117	121	127	127	123	123	124	123	124	122	-1
70	561	551	547	568	597	599	578	584	600	586	576	568	-2
75	249	245	240	250	263	265	256	268	275	265	255	250	-2
80	108	106	105	109	115	114	110	116	122	117	112	109	-2
85	463	448*	444	471	496	487	471	506	527	515	495	477	-3
90	194	188*	191	206	214	206	198	214	230	228	216	204	-3
95	079*	080*	081	088	090*	085	081	093	101*	099*	090	083	-3
100	345*	364*	374*	386*	379*	362*	357	421*	480*	462*	395	353	-4
105	164*	182*	183*	182*	172*	164*	170	213*	246*	230*	184*	161*	-4
110	089*	101*	104*	098*	088*	084*	090	117*	141*	130*	100*	085*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES ROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES PPLY TO THE FIRST DAY OF EACH MONTH
(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24b. Pressures (N/m^2) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
20 DEGREES N													
25	244	242	244	246	250	253	256	257	254	251	248	245	1
30	114	114	115	117	120	121	122	122	121	119	118	116	1
35	562	560	566	583	595	597	600	595	596	585	578	565	0
40	286	286	290	300	307	306	305	303	303	298	294	289	0
45	152	152	154	159	163	162	161	158	160	157	155	152	0
50	816	820	833	861	882	878	866	852	858	850	838	827	-1
55	442	443	446	462	475	474	466	454	461	457	452	442	-1
60	232	231	231	240	248	249	245	240	242	240	239	234	-1
65	117	114	113	119	125	126	123	121	125	122	120	117	-1
70	549	534	528	565	600	592	573	579	606	594	571	556	-2
75	243	240	237	257	271	264	253	261	283	274	256	245	-2
80	105	105	105	113	118	114	109	116	126	122	113	108	-2
85	446	451	450	494	505	479	460	501	550	533	492	459	-3
90	187*	188	191	213	215	201	191	214	236	233	212	199	-3
95	077*	080	080	090*	090*	083	079	090	104*	102*	089	081	-3
100	338*	362	362	386*	382*	361*	354	412*	487*	480*	405	353*	-4
105	160*	178*	175*	178*	175*	167*	168	199*	247*	242*	195*	161*	-4
110	086*	096*	096*	093*	089*	087*	089	109*	138*	137*	109*	087*	-4
30 DEGREES N													
25	239	239	240	244	249	253	259	260	257	253	247	241	1
30	112	112	113	116	118	121	123	123	122	120	116	113	1
35	546	543	552	570	584	599	605	606	597	583	562	552	0
40	275	274	279	291	299	308	309	307	302	295	283	279	0
45	146	144	146	153	159	163	163	161	158	153	148	147	0
50	778	773	781	825	859	886	876	863	845	824	792	788	-1
55	420	413	416	439	463	477	470	462	451	439	425	422	-1
60	217	215	214	229	242	251	246	241	234	228	221	221	-1
65	110	106	106	114	122	125	122	120	118	113	110	111	-1
70	519	504	503	551	587	593	562	563	560	549	525	533	-2
75	236	229	231	253	268	262	245	251	255	248	237	239	-2
80	102	102	103	114	115	111	104	109	112	110	104	105	-2
85	440	439	446	493	485	456	423	459	477	471	448	449	-3
90	184*	187	188	212	199	183	170	189	200	202	192	194	-3
95	778*	784	789	873*	819	737*	688	796	872	876	826	822	-4
100	345*	357	354	380*	351*	327*	317	359	404	413	384	368*	-4
105	163*	171*	169	172*	163*	156*	153	171	199*	207*	192*	173*	-4
110	084*	091*	089	089*	084*	084*	083	090	107*	116*	106*	091*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH
(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24b. Pressures (N/m^2) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
40 DEGREES N													
25	237	239	240	241	247	256	263	264	259	254	246	239	1
30	111	111	112	114	117	122	125	126	124	119	115	111	1
35	529	531	533	554	576	602	622	623	607	578	546	530	0
40	261	264	267	282	298	311	318	319	307	289	270	263	0
45	136	137	139	148	158	166	169	169	162	150	139	136	0
50	720	734	741	801	861	905	912	907	865	801	736	723	-1
55	383	390	392	427	464	487	492	485	461	426	388	382	-1
60	198	202	203	223	244	258	257	252	235	217	200	198	-1
65	100	100	101	111	122	128	128	124	115	106	098	099	-1
70	481	482	487	539	591	607	595	571	528	487	464	477	-2
75	222	223	225	250	267	265	257	250	233	217	210	220	-2
80	100	101	102	112	115	110	104	104	098	094	093	099	-2
85	437*	440	438	478	464	423	395	408	405	402	402	433	-3
90	190*	191	187	198	181	156	145	158	166	172	175	191	-3
95	833*	814	785	813	700	577	569	660	721	751	774	849*	-4
100	379*	366	354	359	308	260	262	301	328	343	365	393*	-4
105	177*	174*	167	165	145	127	132	145*	158*	172	183*	188*	-4
110	899*	908*	885	858	784	719	725	748*	823*	928*	988*	962*	-5
50 DEGREES N													
25	241	243	243	241	246	258	265	265	260	254	245	241	1
30	112	112	112	114	117	123	128	128	124	118	113	112	1
35	527	523	529	553	577	611	640	640	613	564	529	524	0
40	254	255	262	282	300	318	331	330	313	281	255	252	0
45	127	130	135	149	160	171	177	175	165	145	129	125	0
50	659	683	718	804	880	935	961	946	883	767	666	645	-1
55	345	359	380	430	474	508	521	509	471	403	346	336	-1
60	177	185	196	225	250	271	275	266	241	204	177	172	-1
65	089	092	098	112	126	137	139	132	117	099	087	086	-1
70	435	450	475	546	607	652	654	615	537	454	413	420	-2
75	207	211	223	253	276	286	284	268	234	202	191	199	-2
80	095	097	102	114	118	117	111	106	096	087	086	091	-2
85	429*	434	444	475*	459	423	393	390	378	371	381	411	-3
90	191*	192	191*	192*	169*	141	131	140	150	158	169	185	-3
95	873*	843*	804*	769*	619*	480	479	567	633*	694	772	867*	-4
100	401*	377*	365*	348*	276*	214	218	255*	280*	310	364*	412*	-4
105	190*	179*	174*	167*	135*	108	110	122*	131*	151*	180*	201*	-4
110	939*	929*	937*	923*	785*	640	626	629*	656*	778*	933*	992*	-5

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH
(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 24b. Pressures (N/m^2) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
60 DEGREES N													
25	244	241	238	240	249	260	269	270	260	250	244	242	1
30	111	111	110	113	118	125	130	130	124	116	111	110	1
35	509	517	521	545	581	627	653	648	610	556	518	506	0
40	237	246	255	273	299	326	340	335	310	274	247	237	0
45	116	122	130	142	159	176	184	178	163	140	123	116	0
50	059	063	068	076	087	096	101	097	088	074	063	059	0
55	306	325	354	407	470	528	551	526	467	389	330	303	-1
60	155	165	181	210*	248	282	295	280	243	199	168	154	-1
65	079	083	090	106*	125*	144	152	141	121	099	084	078	-1
70	382	397	434	511*	608*	695*	730	676	573	466	404	381	-2
75	183	188	205	240*	280*	313*	322	295	252	213	190	183	-2
80	084	086	094	108*	121*	128*	126	115	103	093	087	085	-2
85	384	393	420	458*	472*	453*	425	397	399	398	393	388	-3
90	174	175	182*	184*	170*	145*	131	134	153	169	178*	179	-3
95	813*	792*	783*	754*	622*	489*	458*	504	619*	737	819*	841	-4
100	376*	359*	355*	341*	280*	216*	198*	216*	265*	325	386*	405	-4
105	181*	174*	177*	176*	145*	112*	101*	102*	119*	150*	184*	195*	-4
110	089*	090*	098*	102*	089*	069*	058*	052*	056*	072*	091*	095*	-4
70 DEGREES N													
25	240	231	225	239	254	265	274	276	262	243	239	240	1
30	105	105	105	111	120	128	133	132	124	113	109	107	1
35	472	485	501	522	586	642	662	650	599	539	511	486	0
40	216	227	242	254	292	330	345	332	301	264	244	227	0
45	103	110	121	130	155	178	185	177	157	135	122	110	0
50	052	055	062	069	083	097	102	096	084	071	063	056	0
55	266	279	319	363	456	537	564	525	450	374	333	294	-1
60	134	140	162	188*	239*	288*	307	281	237	191	169	150	-1
65	067	069	079	093*	123*	150*	159	145	120	095	084	075	-1
70	317	321	372	448*	596*	731*	779	709	582	452	396	357	-2
75	148	147	171*	209*	283*	335*	348	316	262	207	184	167	-2
80	067	066	076*	093*	121*	136*	137	125	110	092	084	077	-2
85	305	295	339*	392*	477*	483*	452*	430	430*	400*	387*	353	-3
90	138	133	146*	158*	170*	152*	135*	138	164*	170*	176*	162	-3
95	646*	600*	645*	658*	649*	526*	456*	489*	638*	735*	811*	764*	-4
100	301*	278*	298*	305*	292*	230*	191*	199*	261*	316*	372*	361*	-4
105	145*	135*	153*	164*	162*	124*	098*	091*	110*	139*	174*	172*	-4
110	070*	071*	086*	099*	100*	077*	056*	045*	048*	061*	081*	082*	-4

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER, THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

(1NEWTON/M SQ = 10DYNES/CM SQ)

Table 25. Log (pressure) for the Values in Table 24b. The annual mean value and the monthly differences from this value

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES N													
25	3.399	-001	-001	+000	+001	+001	+000	-001	-001	+000	+001	+001	+000
30	3.074	-003	-003	-001	+002	+004	+001	-003	-003	-001	+002	+004	+001
35	2.769	-004	-004	-004	+002	+006	+004	-004	-004	-004	+002	+006	+004
40	2.481	-005	-007	-006	+004	+009	+004	-005	-007	-006	+004	+009	+004
45	2.205	-008	-008	-004	+007	+010	+003	-008	-008	-004	+007	+010	+003
50	1.937	-012	-009	-003	+010	+012	+002	-012	-009	-003	+010	+012	+002
55	1.669	-012	-009	-002	+010	+012	+001	-012	-009	-002	+010	+012	+001
60	1.392	-010	-007	-005	+006	+012	+003	-010	-007	-005	+006	+012	+003
65	1.091	-004	-006	-006	+001	+009	+005	-004	-006	-006	+001	+009	+005
70	0.762	-001	-001	-006	-002	+003	+006	-001	-001	-006	-002	+003	+006
75	0.406	+000	+002	+001	-003	-002	+001	+000	+002	+001	-003	-002	+001
80	0.044	-001	+001	-001	-002	+001	+003	-001	+001	-001	-002	+001	+003
85	*1.680	-006	-009	-002	+001	+009	+007	-006	-009	-002	+001	+009	+007
90	*1.314	-020	-013	-001	+012	+015	+005	-020	-013	-001	+012	+015	+005
95	*2.940	-035	-008	+016	+024	+008	-009	-035	-008	+016	+024	+008	-009
100	*2.587	-043	+010	+035	+032	-009	-031	-043	+010	+035	+032	-009	-031
105	*2.270	-045	+029	+059	+036	-033	-059	-045	+029	+059	+036	-033	-059
110	*2.008	-055	+044	+078	+042	-050	-084	-055	+044	+078	+042	-050	-084
10 DEGREES N													
25	3.398	-005	-007	-007	+000	+006	+005	+004	+006	+005	+000	-001	-005
30	3.074	-007	-010	-007	+001	+007	+005	+003	+004	+004	+001	+001	-003
35	2.768	-008	-011	-008	+001	+008	+007	+003	+004	+002	+001	+002	-002
40	2.479	-009	-013	-006	+006	+013	+009	+000	-002	-001	+001	+002	-001
45	2.203	-012	-011	-004	+007	+014	+010	-003	-004	-001	+002	+004	-002
50	1.935	-015	-011	-001	+011	+018	+010	-007	-009	-002	+004	+004	-004
55	1.667	-014	-008	-003	+009	+016	+010	-007	-007	-001	+004	+006	-004
60	1.388	-013	-011	-006	+005	+017	+012	-005	-007	+001	+003	+006	-003
65	1.088	-011	-014	-018	-004	+015	+016	+001	+002	+005	+002	+004	-001
70	0.761	-011	-019	-022	-006	+015	+017	+001	+006	+017	+007	+000	-006
75	0.409	-014	-020	-028	-012	+011	+013	-001	+018	+030	+014	-003	-011
80	0.049	-015	-025	-028	-012	+010	+008	-006	+016	+037	+021	+001	-012
85	*1.684	-018	-033	-037	-011	+011	+003	-011	+020	+038	+027	+010	-005
90	*1.317	-029	-042	-035	-003	+013	-002	-020	+014	+045	+041	+017	-007
95	*2.943	-045	-038	-034	+002	+011	-012	-033	+026	+063	+055	+011	-022
100	*2.591	-053	-030	-018	-004	-012	-032	-038	+033	+091	+074	+006	-043
105	*2.273	-057	-014	-010	-013	-038	-057	-043	+055	+117	+088	-008	-066
110	*2.010	-061	-005	+005	-018	-064	-087	-054	+060	+140	+104	-010	-080

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1NEWTON/M SQ = 10DYNES/CM SQ)

Table 25. Log (pressure) for the Values in Table 24b (Contd.)

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20 DEGREES N													
25	3.397	-009	-013	-009	-006	+002	+006	+011	+014	+009	+002	-003	-007
30	3.073	-014	-017	-012	-003	+005	+009	+012	+013	+010	+004	-002	-008
35	2.765	-015	-017	-012	+001	+010	+011	+013	+010	+011	+003	-003	-013
40	2.473	-017	-017	-010	+004	+014	+013	+012	+008	+008	+002	-004	-012
45	2.196	-015	-016	-009	+006	+015	+014	+010	+002	+007	+001	-004	-014
50	1.929	-017	-015	-008	+006	+017	+015	+009	+002	+005	+001	-005	-011
55	1.659	-014	-013	-010	+006	+017	+017	+010	-002	+005	+000	-004	-014
60	1.379	-014	-016	-016	+001	+016	+017	+011	+002	+005	+001	-001	-009
65	1.079	-012	-022	-028	-005	+018	+020	+011	+002	+016	+007	+000	-010
70	0.756	-017	-029	-034	-004	+022	+016	+002	+007	+026	+017	+001	-011
75	0.410	-024	-030	-036	+000	+023	+012	-008	+007	+042	+028	-001	-021
80	0.053	-030	-030	-032	+001	+018	+003	-016	+014	+047	+035	+002	-021
85	*1.686	-036	-032	-033	+008	+017	-005	-023	+014	+055	+041	+006	-024
90	*1.316	-045	-040	-034	+013	+018	-012	-034	+016	+058	+051	+011	-017
95	*2.940	-055	-038	-036	+014	+015	-019	-041	+015	+078	+068	[illegible]	-033
100	*2.591	-062	-033	-032	-004	-009	-034	-042	+023	+096	+090	+016	-044
105	*2.272	-067	-023	-028	-022	-028	-049	-046	+026	+120	+111	+018	-064
110	*2.005	-073	-022	-025	-038	-054	-067	-054	+031	+133	+131	+031	-065
30 DEGREES N													
25	3.395	-016	-018	-015	-007	+001	+008	+018	+019	+015	+007	-002	-013
30	3.071	-020	-021	-016	-006	+003	+013	+020	+021	+017	+008	-006	-016
35	2.760	-022	-025	-017	-004	+007	+018	+022	+023	+016	+006	-010	-018
40	2.465	-026	-028	-020	-001	+011	+023	+026	+022	+016	+005	-014	-020
45	2.186	-022	-028	-021	-001	+015	+026	+026	+021	+013	+000	-015	-019
50	1.916	-025	-028	-024	+000	+018	+031	+027	+020	+011	+000	-017	-020
55	1.645	-022	-029	-026	-002	+021	+033	+027	+019	+010	-002	-017	-019
60	1.362	-025	-029	-030	-002	+022	+038	+030	+020	+008	-004	-017	-017
65	1.060	-019	-034	-035	-005	+027	+038	+026	+019	+010	-005	-017	-013
70	0.737	-022	-034	-036	+004	+032	+036	+013	+013	+011	+002	-017	-011
75	0.391	-019	-031	-027	+012	+036	+027	-002	+008	+016	+003	-016	-012
80	0.032	-023	-022	-020	+026	+030	+013	-016	+006	+016	+011	-013	-012
85	*1.660	-016	-017	-011	+033	+026	-001	-034	+001	+018	+013	-009	-008
90	*1.282	-017	-011	-009	+043	+017	-020	-053	-006	+019	+024	+001	+005
95	*2.906	-015	-011	-009	+035	+008	-038	-068	-005	+035	+037	+011	+009
100	*2.560	-022	-007	-011	+019	-015	-046	-060	-005	+047	+056	+025	+006
105	*2.240	-029	-008	-012	-005	-029	-048	-055	-008	+058	+075	+042	-003
110	*3.969	-043	-008	-019	-019	-043	-046	-047	-015	+063	+098	+058	-008

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1NEWTON/M SQ = 10DYNES/CM SQ)

Table 25. Log (pressure) for the Values in Table 24b (Contd.)

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40 DEGREES N													
25	3.396	-020	-017	-016	-013	-003	+012	+023	+025	+017	+009	-005	-017
30	3.069	-025	-023	-021	-012	+001	+017	+029	+031	+023	+008	-010	-024
35	2.755	-032	-030	-028	-011	+005	+024	+039	+039	+028	+006	-018	-031
40	2.459	-041	-037	-032	-008	+015	+034	+044	+046	+029	+003	-027	-039
45	2.178	-046	-040	-036	-007	+021	+041	+049	+049	+031	-001	-036	-045
50	1.908	-050	-042	-038	-004	+027	+049	+052	+050	+029	-004	-041	-049
55	1.635	-052	-044	-041	-005	+032	+053	+057	+051	+029	-006	-046	-053
60	1.350	-053	-045	-042	-003	+037	+061	+061	+051	+021	-014	-049	-052
65	1.045	-047	-044	-043	+000	+041	+063	+063	+049	+014	-021	-053	-051
70	0.721	-039	-038	-034	+011	+051	+063	+053	+036	+002	-033	-054	-042
75	0.374	-027	-026	-022	+024	+053	+050	+035	+025	-007	-037	-053	-032
80	0.011	-011	-008	-004	+039	+050	+030	+005	+005	-019	-037	-045	-015
85	*1.630	+010	+013	+011	+049	+036	-005	-033	-020	-023	-026	-027	+006
90	*1.245	+035	+036	+026	+052	+012	-051	-084	-047	-025	-011	-002	+036
95	*2.868	+053	+043	+027	+043	-022	-106	-113	-048	-010	+008	+021	+061
100	*2.525	+054	+039	+024	+030	-037	-110	-106	-047	-008	+011	+037	+070
105	*2.207	+041	+033	+017	+012	-045	-104	-087	-046	-007	+028	+055	+066
110	*3.931	+023	+027	+016	+003	-036	-074	-070	-057	-015	+037	+064	+053

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
50 DEGREES N													
25	3.399	-016	-012	-013	-016	-007	+013	+025	+025	+017	+006	-009	-016
30	3.071	-021	-023	-022	-016	-002	+019	+035	+037	+023	+001	-018	-021
35	2.755	-034	-037	-031	-012	+006	+030	+051	+051	+032	-004	-032	-036
40	2.456	-052	-050	-038	-005	+020	+046	+063	+062	+039	-008	-049	-055
45	2.173	-068	-059	-042	+000	+031	+059	+076	+070	+043	-012	-064	-075
50	1.901	-082	-067	-045	+005	+044	+070	+082	+075	+045	-016	-077	-091
55	1.627	-089	-072	-047	+006	+049	+080	+090	+080	+046	-022	-087	-101
60	1.342	-094	-074	-049	+009	+056	+090	+097	+082	+040	-032	-095	-107
65	1.040	-088	-074	-048	+009	+059	+095	+104	+081	+030	-044	-100	-104
70	0.717	-079	-064	-041	+020	+066	+097	+098	+071	+013	-060	-101	-094
75	0.373	-057	-049	-025	+031	+067	+083	+081	+055	-005	-067	-093	-075
80	0.007	-030	-021	-001	+050	+065	+060	+039	+020	-025	-067	-074	-048
85	*1.619	+014	+019	+028	+058	+043	+008	-024	-028	-041	-049	-037	-005
90	*1.224	+058	+060	+057	+060	+004	-075	-108	-076	-048	-026	+003	+044
95	*2.845	+096	+081	+060	+041	-053	-164	-165	-092	-044	-004	+043	+093
100	*2.503	+100	+074	+059	+039	-062	-173	-165	-097	-056	-011	+058	+112
105	*2.187	+091	+066	+053	+035	-057	-154	-147	-099	-069	-010	+067	+115
110	*3.911	+062	+057	+061	+054	-016	-104	-114	-112	-094	-019	+059	+086

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1NEWTON/M SQ = 10DYNES/CM SQ)

Table 25. Log (pressure) for the Values in Table 24b (Contd.)

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
60 DEGREES N													
25	3.399	-012	-017	-022	-018	-003	+016	+031	+032	+016	-002	-012	-015
30	3.070	-026	-026	-029	-017	+003	+028	+045	+045	+024	-005	-023	-028
35	2.753	-046	-039	-036	-016	+011	+045	+062	+059	+032	-008	-039	-049
40	2.450	-075	-059	-043	-014	+026	+063	+082	+075	+042	-011	-056	-075
45	2.164	-097	-076	-051	-010	+038	+081	+100	+088	+048	-017	-073	-101
50	1.889	-120	-093	-060	-007	+050	+095	+114	+098	+053	-020	-088	-121
55	1.616	-130	-104	-067	-007	+056	+107	+125	+105	+053	-026	-097	-134
60	1.333	-141	-115	-075	-010	+062	+117	+138	+114	+053	-034	-107	-144
65	1.035	-138	-118	-081	-011	+062	+123	+146	+116	+048	-040	-112	-144
70	0.717	-135	-118	-030	-009	+067	+125	+146	+113	+041	-049	-111	-136
75	0.378	-116	-104	-067	+003	+069	+118	+130	+093	+024	-049	-099	-116
80	0.011	-088	-076	-037	+021	+074	+096	+088	+051	+004	-042	-070	-083
85	*1.618	-033	-024	+005	+043	+056	+038	+010	-020	-017	-018	-023	-030
90	*1.216	+025	+028	+044	+048	+015	-055	-098	-090	-032	+011	+035	+036
95	*2.836	+074	+063	+058	+041	-043	-147	-175	-134	-045	+031	+077	+089
100	*2.492	+083	+064	+059	+041	-045	-158	-194	-157	-069	+020	+095	+116
105	*2.180	+078	+060	+068	+066	-018	-130	-175	-171	-105	-004	+084	+110
110	*3.903	+045	+053	+088	+105	+045	-065	-142	-189	-154	-045	+055	+073
70 DEGREES N													
25	3.396	-017	-032	-045	-018	+010	+028	+042	+044	+022	-011	-018	-015
30	3.064	-042	-044	-044	-020	+015	+043	+059	+056	+028	-010	-027	-035
35	2.744	-070	-058	-044	-027	+024	+063	+077	+069	+033	-012	-035	-058
40	2.436	-102	-080	-052	-031	+030	+083	+102	+086	+042	-014	-049	-081
45	2.147	-132	-106	-065	-034	+044	+103	+121	+101	+048	-017	-061	-105
50	1.870	-158	-133	-080	-034	+050	+118	+140	+113	+054	-020	-070	-119
55	1.598	-174	-153	-094	-038	+061	+132	+153	+121	+054	-026	-076	-130
60	1.316	-188	-170	-108	-043	+062	+144	+170	+133	+058	-035	-089	-140
65	1.021	-196	-185	-123	-051	+069	+154	+181	+142	+060	-042	-097	-149
70	0.703	-203	-196	-133	-052	+072	+160	+188	+148	+062	-048	-106	-151
75	0.364	-194	-197	-132	-045	+087	+160	+178	+136	+054	-048	-099	-141
80	*1.994	-169	-174	-111	-026	+088	+141	+142	+103	+048	-032	-070	-109
85	*1.597	-112	-127	-067	-003	+082	+087	+059	+037	+036	+005	-009	-049
90	*1.186	-046	-062	-023	+014	+045	-004	-057	-046	+028	+045	+059	+024
95	*2.803	+008	-025	+007	+015	+010	-082	-143	-113	+002	+064	+106	+081
100	*2.453	+026	-009	+021	+032	+012	-090	-171	-153	-036	+046	+118	+105
105	*2.143	+018	-014	+044	+073	+066	-049	-153	-184	-100	+000	+097	+094
110	*3.864	-018	-014	+073	+133	+138	+023	-116	-209	-178	-076	+044	+047

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1NEWTON/M SQ = 10DYNES/CM SQ)

Table 26a. Densities (kg/m^3) 25 to 110 km. Insert decimal point on the right of the three digits and multiply by 10^N

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	N
JANUARY 1									
25	400	393	392	381	377	382	395	403	-4
30	175	175	173	171	171	176	179	176	-4
35	820	815	805	800	791	812	813	772	-5
40	404	400	386	374	367	371	361	338	-5
45	207	203	196	189	180	177	168	153	-5
50	108	107	104	100	094	089	081	072	-5
55	585	581	575	554	511	457	420	357	-6
60	327	325	320	302	277	248	218	192	-6
65	182	179	174	164	146	131	115	100	-6
70	952	926	906	837	755	661	581	497	-7
75	444	431	421	403	365	330	289	241	-7
80	195	190	187	180	171	157	137	110	-7
85	850	832	809	791	760*	722*	634	503	-8
90	370	365	349*	339*	333*	320*	283	225	-8
95	148	146*	139*	138*	141*	143*	131*	103*	-8
100	580	574*	560*	571*	622*	645*	593*	474*	-9
105	242	236*	234*	244*	271*	294*	278*	224*	-9
110	108	106*	104*	107*	119*	128*	124*	101*	-9
FEBRUARY 1									
25	400	393	386	379	382	391	387	377	-4
30	178	174	172	171	173	178	175	168	-4
35	823	813	799	791	790	799	804	765	-5
40	403	393	386	375	368	366	366	348	-5
45	205	201	195	187	181	176	173	162	-5
50	108	106	104	099	095	090	085	077	-5
55	591	592	580	545	521	483	446	390	-6
60	334	332	325	303	284	261	235	203	-6
65	182	181	174	161	149	136	122	105	-6
70	943	914	873	809	760	694	612	516	-7
75	444	425	408	382	364	338	300	243	-7
80	198	189	185	177	171	160	141	111	-7
85	845	812*	817	785	766	738	654	494	-8
90	360	343*	347	342	341	331	295	222	-8
95	147*	140*	139	137	142	145*	133*	099*	-8
100	610*	571*	574	574	598	619*	578*	439*	-9
105	264*	246*	249*	247*	257*	266*	254*	195*	-9
110	125*	114*	114*	113*	116*	118*	114*	089*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W

(1KG/M CU = 10POWER(-3)GM/CC)

Table 26a. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	LATITUDE (DEGREES N) 0	10	20	30	40	50	60	70	N
MARCH 1									
25	399	387	388	380	381	390	381	354	-4
30	178	175	174	172	174	177	173	162	-4
35	827	811	805	802	787	795	785	755	-5
40	400	397	390	382	371	368	365	356	-5
45	204	202	198	191	183	180	177	170	-5
50	109	109	106	101	096	094	090	084	-5
55	605	604	591	555	524	509	479	439	-6
60	340	343	331	305	288	276	258	233	-6
65	185	182	174	161	150	145	134	121	-6
70	931	912	863	800	760	735	668	594	-7
75	440	417	400	384	368	358	325	282*	-7
80	195	186	183	177	174	172	155	129*	-7
85	841	793	803	796	778	776	724	589*	-8
90	361	345	350	345	340	346*	323*	255*	-8
95	153*	140	142	139	138	141*	136*	108*	-8
100	644*	591*	583	574	578	589*	559*	451*	-9
105	279*	249*	247*	248	247	251*	241*	200*	-9
110	131*	117*	114*	110	110	112*	111*	094*	-9
APRIL 1									
25	398	394	386	383	379	378	375	376	-4
30	178	178	174	174	173	173	173	174	-4
35	829	823	822	814	798	793	802	793	-5
40	406	406	402	396	384	381	377	354	-5
45	208	208	205	198	192	192	187	175	-5
50	112	112	110	106	103	103	098	089	-5
55	623	622	610	582	565	565	541	485	-6
60	352	350	340	323	311	314	294*	254*	-6
65	189	186	179	168	164	165	155*	139*	-6
70	958	942	903	864	838	846	788*	697*	-7
75	440	435	435	416	409	412	389*	341*	-7
80	193	190	196	196	195	200	186*	162*	-7
85	826	821	864	872	871	889*	853*	730*	-8
90	368	364	382	388	373	374*	353*	301*	-8
95	159*	157	163*	159*	147	139*	135*	115*	-8
100	673*	648*	669*	654*	603	560*	522*	445*	-9
105	282*	265*	269*	265*	253	234*	223*	192*	-9
110	126*	116*	115*	114*	108	107*	106*	095*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
(1KG/M CU = 10POWER(-3)GM/CC)

Table 26a. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70	N
				LATITUDE (DEGREES N)					
MAY 1									
25	396	400	391	389	384	381	385	398	-4
30	178	180	177	177	177	176	178	181	-4
35	829	832	835	830	816	811	823	857	-5
40	411	414	411	402	396	395	399	399	-5
45	212	212	209	204	202	201	201	200	-5
50	113	114	112	109	109	110	109	104	-5
55	621	628	624	608	605	616	606	586	-6
60	350	351	344	334	338	344	341	324*	-6
65	193	191	184	180	179	184	183*	178*	-6
70	984	985	958	930	935	957	945*	906*	-7
75	444	458	465	457	456	469	466*	467*	-7
80	191	200	208	207	211	221	225*	224*	-7
85	838	872	897	894	903	941	978*	990*	-8
90	384	383	390	375	366	365*	372*	355*	-8
95	163*	166*	166*	151	131	119*	119*	122*	-8
100	663*	670*	665*	602*	510	439*	424*	422*	-9
105	262*	266*	270*	246*	210	178*	173*	178*	-9
110	111*	112*	115*	107*	094	085*	085*	088*	-9
JUNE 1									
25	397	400	395	392	396	399	397	403	-4
30	177	178	180	181	182	183	183	187	-4
35	828	835	845	848	848	851	870	897	-5
40	411	413	412	414	413	416	426	436	-5
45	210	211	209	209	210	215	219	223	-5
50	111	112	111	112	114	117	119	120	-5
55	606	617	619	622	631	649	669	673	-6
60	339	341	343	347	356	368	379	380*	-6
65	187	189	188	188	193	202	209	213*	-6
70	098	099	097	097	100	106	110*	113*	-6
75	447	463	458	461	474	511	547*	580*	-7
80	193	202	204	204	211	232	257*	275*	-7
85	085	087	087	086	087	094	104*	113*	-7
90	384	380	372	355	335	333	350*	355*	-8
95	160*	158	152	134*	109	096	099*	105*	-8
100	636*	633*	616*	535*	412	330	328*	345*	-9
105	252*	256*	252*	224*	171	136	132*	140*	-9
110	106*	109*	113*	104*	083	067	066*	069*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
(1KG/M CU = 10POWER(-3)GM/CC)

Table 26a. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70	N
				LATITUDE (DEGREES N)					
JULY 1									
25	400	399	401	402	408	407	407	413	-4
30	178	179	182	185	186	187	190	194	-4
35	820	840	856	863	881	891	903	919	-5
40	404	410	415	419	428	437	444	452	-5
45	207	208	209	211	217	226	230	231	-5
50	108	109	111	112	116	121	125	125	-5
55	585	591	609	615	641	672	695	700	-6
60	327	328	338	343	357	374	393	400	-6
65	182	183	186	188	195	207	219	225	-6
70	095	095	095	095	100	108	117	122	-6
75	444	446	440	434	468	524	587	625	-7
80	195	196	195	191	203	231	265	291	-7
85	085	085	084	080	082	089	103	113*	-7
90	370	370	358	329	302	297	314	332*	-8
95	148	148	142	122	102	090	091*	094*	-8
100	580	591	581	500	399	333	310*	305*	-9
105	242	247	245	215	178	143	130*	125*	-9
110	108	112	113	103	086	070	062*	058*	-9
AUGUST 1									
25	400	403	406	406	408	403	411	423	-4
30	178	179	184	185	188	188	192	196	-4
35	823	845	853	872	882	895	907	924	-5
40	403	410	417	420	429	440	445	445	-5
45	205	208	206	210	219	225	227	225	-5
50	108	108	110	111	117	120	122	120	-5
55	591	593	594	609	642	666	673	665	-6
60	334	326	330	336	353	370	379	373	-6
65	182	182	179	182	192	201	208	207	-6
70	094	093	093	092	096	102	110	112	-6
75	444	455	440	431	445	488	542	568	-7
80	198	203	202	194	197	216	244	261	-7
85	085	090	089	085	082	084	091	101	-7
90	360	384	390	351	305	287	293	321	-8
95	147*	161	158	139	114	101	096	099*	-8
100	610*	658*	659*	583	479	408*	360*	349*	-9
105	264*	287*	281*	252	214*	182*	154*	142*	-9
110	125*	133*	129*	112	096*	081*	068*	052*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
(1KG/M CU = 10POWER(-3)GM/CC)

Table 26a. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	0	10	20	30	40	50	60	70	N
				LATITUDE (DEGREES N)					
SEPTEMBER 1									
25	399	400	399	400	401	403	401	407	-4
30	178	180	181	185	185	185	186	188	-4
35	827	841	854	863	873	872	871	873	-5
40	400	406	412	415	418	424	422	416	-5
45	204	206	208	208	211	214	212	205	-5
50	109	109	110	109	112	114	113	108	-5
55	605	600	606	600	620	631	616	587	-6
60	340	336	328	326	340	347	339	323	-6
65	185	181	179	175	178	183	182	175	-6
70	931	945	939	895	880	903	932	922	-7
75	440	460	468	432	409	419	451	454	-7
80	195	212	217	196	180	184	200	209	-7
85	841	922	967	865	762	744	809	865*	-8
90	361	403	417	361	302	282	300	329*	-8
95	153*	169*	174*	147	122	111*	113*	123*	-8
100	644*	721*	741*	633	526	464*	459*	479*	-9
105	279*	318*	332*	280*	233*	202*	196*	197*	-9
110	131*	151*	154*	127*	104*	088*	083*	080*	-9
OCTOBER 1									
25	398	394	391	395	400	402	395	382	-4
30	178	178	179	181	182	184	180	175	-4
35	829	832	839	843	845	836	827	810	-5
40	406	405	404	408	402	393	390	378	-5
45	208	206	204	202	199	193	189	183	-5
50	112	110	108	106	104	101	097	093	-5
55	623	611	598	584	574	550	529	505	-6
60	352	341	329	321	313	297	282	271	-6
65	189	184	177	167	164	155	149	142	-6
70	958	945	928	873	808	754	745	719	-7
75	440	448	455	418	372	349	358	345	-7
80	193	202	211	192	167	155	164	157	-7
85	826	883	928	842	722	669	714	706*	-8
90	368	396	409	361	303	277	298	302*	-8
95	159*	169*	170*	147	128	119	128	130*	-8
100	673*	719*	731*	631	534	502	546	553*	-9
105	232*	310*	322*	276*	237	220*	239*	241*	-9
110	126*	142*	150*	132*	110*	100*	104*	101*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W

(1KG/M CU = 10POWER(-3)GM/CC)

Table 26a. Densities (kg/m^3) 25 to 110 km (Contd.)

	LATITUDE (DEGREES N)								
KM	0	10	20	30	40	50	60	70	N
NOVEMBER 1									
25	396	394	389	391	391	392	393	387	-4
30	178	177	177	178	178	179	178	173	-4
35	829	831	828	823	816	815	805	792	-5
40	411	406	399	389	382	372	367	361	-5
45	212	208	201	194	185	178	173	169	-5
50	113	111	107	102	096	090	085	084	-5
55	621	609	585	560	522	473	451	453	-6
60	350	343	329	309	286	253	239	241	-6
65	193	188	179	165	149	132	124	127	-6
70	984	960	926	846	749	654	625	627	-7
75	444	439	436	401	354	313	303	299	-7
80	191	192	197	183	160	144	144	137	-7
85	838	849	861	796	703	654	655	633*	-8
90	384	390	386	345	304	283	294*	288*	-8
95	163*	162	156	141	128	124	131*	132*	-8
100	663*	668	651	593	555	559*	606*	602*	-9
105	262*	270*	272*	260*	252*	259*	282*	281*	-9
110	111*	116*	125*	123*	119*	121*	129*	125*	-9
DECEMBER 1									
25	397	390	385	384	384	380	390	399	-4
30	177	175	177	172	172	177	178	176	-4
35	828	821	809	801	789	811	805	776	-5
40	411	405	392	381	369	372	362	348	-5
45	210	207	196	191	180	176	166	158	-5
50	111	109	105	101	095	087	080	076	-5
55	606	598	576	555	510	458	418	400	-6
60	339	332	321	305	279	242	218	214	-6
65	187	185	175	164	146	126	113	111	-6
70	980	951	918	859	749	642	575	555	-7
75	447	435	422	409	361	318	287	259	-7
80	193	189	189	184	169	150	138	125	-7
85	851	831	808	794	749	691	634	574	-8
90	384	378	366	347	327	302	286	260	-8
95	160*	156	149	145	141*	136*	131	120*	-8
100	636*	617	605*	609*	627*	633*	619	563*	-9
105	252*	244*	239*	256*	281*	305*	302*	272*	-9
110	106*	103*	106*	114*	126*	137*	137*	124*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W

(1KG/M CU = 10POWER(-3)GM/CC)

Table 26b. Densities (kg/m^3) 25 to 110 km. Insert decimal point on the right of the three digits and multiply by 10^N

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
0 DEGREES N													
25	400	400	399	398	396	397	400	400	399	398	396	397	-4
30	178	178	178	178	178	177	178	178	178	178	178	177	-4
35	820	823	827	829	829	828	820	823	827	829	829	828	-5
40	404	403	400	406	411	411	404	403	400	406	411	411	-5
45	207	205	204	208	212	210	207	205	204	208	212	210	-5
50	108	108	109	112	113	111	108	108	109	112	113	111	-5
55	585	591	605	623	621	606	585	591	605	623	621	606	-6
60	327	334	340	352	350	339	327	334	340	352	350	339	-6
65	182	182	185	189	193	187	182	182	185	189	193	187	-6
70	952	943	931	958	984	980	952	943	931	958	984	980	-7
75	444	444	440	440	444	447	444	444	440	440	444	447	-7
80	195	198	195	193	191	193	195	198	195	193	191	193	-7
85	850	845	841	826	838	851	850	845	841	826	838	851	-8
90	370	360	361	368	384	384	370	360	361	368	384	384	-8
95	148	147*	153*	159*	163*	160*	148	147*	153*	159*	163*	160*	-8
100	580	610*	644*	673*	663*	636*	580	610*	644*	673*	663*	636*	-9
105	242	264*	279*	282*	262*	252*	242	264*	279*	282*	262*	252*	-9
110	108	125*	131*	126*	111*	106*	108	125*	131*	126*	111*	106*	-9
10 DEGREES N													
25	393	393	387	394	400	400	399	403	400	394	394	390	-4
30	175	174	175	178	180	178	179	179	180	178	177	175	-4
35	815	813	811	823	832	835	840	845	841	832	831	821	-5
40	400	393	397	406	414	413	410	410	406	405	406	405	-5
45	203	201	202	208	212	211	208	208	206	206	208	207	-5
50	107	106	109	112	114	112	109	108	109	110	111	109	-5
55	581	592	604	622	628	617	591	593	600	611	609	598	-6
60	325	332	343	350	351	341	328	326	336	341	343	332	-6
65	179	181	182	186	191	189	183	182	181	184	188	185	-6
70	926	914	912	942	985	989	954	933	945	945	960	951	-7
75	431	425	417	435	458	463	446	455	460	448	439	435	-7
80	190	189	186	190	200	202	196	203	212	202	192	189	-7
85	832	812*	793	821	872	870	846	899	922	883	849	831	-8
90	365	343*	345	364	383	380	370	384	403	396	390	378	-8
95	146*	140*	140	157	166*	158	148	161	169*	169*	162	156	-8
100	574*	571*	591*	648*	670*	633*	591	658*	721*	719*	668	617	-9
105	236*	246*	249*	265*	266*	256*	247	287*	318*	310*	270*	244*	-9
110	106*	114*	117*	116*	112*	109*	112	133*	151*	142*	116*	103*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

(1KG/M CU = 10POWER(-3) GM/CC)

Table 26b. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
20 DEGREES N													
25	392	386	388	386	391	395	401	406	399	391	389	385	-4
30	173	172	174	174	177	180	182	184	181	179	177	177	-4
35	805	799	805	822	835	845	856	853	854	839	828	809	-5
40	386	386	390	402	411	412	415	417	412	404	399	392	-5
45	196	195	198	205	209	209	209	206	208	204	201	196	-5
50	104	104	106	110	112	111	111	110	110	108	107	105	-5
55	575	580	591	610	624	619	609	594	606	598	585	576	-6
60	320	325	331	340	344	343	338	330	328	329	329	321	-6
65	174	174	174	179	184	188	186	179	179	177	179	175	-6
70	906	873	863	903	958	968	955	930	939	928	926	918	-7
75	421	408	400	435	465	458	440	440	468	455	436	422	-7
80	187	185	183	196	208	204	195	202	217	211	197	189	-7
85	809	817	803	864	897	869	838	889	967	928	861	808	-8
90	349*	347	350	382	390	372	358	390	417	409	386	366	-8
95	139*	139	142	163*	166*	152	142	158	174*	170*	156	149	-8
100	560*	574	583	669*	665*	616*	581	659*	741*	731*	651	605*	-9
105	234*	249*	247*	269*	270*	252*	245	281*	332*	322*	272*	239*	-9
110	104*	114*	114*	115*	115*	113*	113	129*	154*	150*	125*	106*	-9
30 DEGREES N													
25	381	379	380	383	389	392	402	406	400	395	391	384	-4
30	171	171	172	174	177	181	185	185	185	181	178	172	-4
35	800	791	802	814	830	848	863	872	863	843	823	301	-5
40	374	375	382	396	402	414	419	420	415	408	389	381	-5
45	189	187	191	198	204	209	211	210	208	202	194	191	-5
50	100	099	101	106	109	112	112	111	109	106	102	101	-5
55	554	545	555	582	608	622	615	609	600	584	560	555	-6
60	302	303	305	323	334	347	343	336	326	321	309	305	-6
65	164	161	161	168	180	188	186	182	175	167	165	164	-6
70	837	809	800	864	930	969	946	925	895	873	846	859	-7
75	403	382	384	416	457	461	434	431	432	418	401	409	-7
80	180	177	177	196	207	204	191	194	196	192	183	184	-7
85	791	785	796	872	894	863	804	850	865	842	796	794	-8
90	339*	342	345	388	375	355	329	351	361	361	345	347	-8
95	138*	137	139	159*	151	134*	122	139	147	147	141	145	-8
100	571*	574	574	654*	602*	535*	500	583	633	631	593	609*	-9
105	244*	247*	248	265*	246*	224*	215	252	280*	276*	260*	256*	-9
110	107*	113*	110	114*	107*	104*	103	112	127*	132*	123*	114*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH
(1KG/M CU = 10POWER(-3)GM/CC)

Table 26b. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
40 DEGREES N													
25	377	382	381	379	384	396	408	408	401	400	391	384	-4
30	171	173	174	173	177	182	186	188	185	182	178	172	-4
35	791	790	787	798	816	848	881	882	873	845	816	789	-5
40	367	368	371	384	396	413	428	429	418	402	382	369	-5
45	180	181	183	192	202	210	217	219	211	199	185	180	-5
50	094	095	096	103	109	114	116	117	112	104	096	095	-5
55	511	521	524	565	605	631	641	642	620	574	522	510	-6
60	277	284	288	311	338	356	357	353	340	313	286	279	-6
65	146	149	150	164	179	193	195	192	178	164	149	146	-6
70	075	076	076	084	094	100	100	096	088	081	075	075	-6
75	365	364	368	409	456	474	468	445	409	372	354	361	-7
80	171	171	174	195	211	211	203	197	180	167	160	169	-7
85	760*	766	778	871	903	865	824	816	762	722	703	749	-8
90	333*	341	340	373	366	335	302	305	302	303	304	327	-8
95	141*	142	138	147	131	109	102	114	122	128	128	141*	-8
100	622*	598	578	603	510	412	399	479	526	534	555	627*	-9
105	271*	257*	247	253	210	171	178	214*	233*	237	252*	281*	-9
110	119*	116*	110	108	094	083	086	096*	104*	110*	119*	126*	-9
50 DEGREES N													
25	382	391	390	378	381	399	407	403	403	402	392	380	-4
30	176	178	177	173	176	183	187	188	185	184	179	177	-4
35	812	799	795	793	811	851	891	895	872	836	815	811	-5
40	371	366	368	381	395	416	437	440	424	393	372	372	-5
45	177	176	180	192	201	215	226	225	214	193	178	176	-5
50	089	090	094	103	110	117	121	120	114	101	090	087	-5
55	467	483	509	565	616	649	672	666	631	550	473	458	-6
60	248	261	276	314	344	368	374	370	347	297	253	242	-6
65	131	136	145	165	184	202	207	201	183	155	132	126	-6
70	066	069	074	085	096	106	108	102	090	075	065	064	-6
75	330	338	358	412	469	511	524	488	419	349	313	318	-7
80	157	160	172	200	221	232	231	216	184	155	144	150	-7
85	722*	738	776	889*	941	945	894	843	744	669	654	691	-8
90	320*	331	346*	374*	365*	333	297	287	282	277	283	302	-8
95	143*	145*	141*	139*	119*	096	090	101	111*	119	124	136*	-8
100	645*	619*	589*	560*	439*	330	333	408*	464*	502	559*	633*	-9
105	294*	266*	251*	234*	178*	136	143	182*	202*	220*	259*	305*	-9
110	128*	118*	112*	107*	085*	067	070	081*	088*	100*	121*	137*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH
(1KG/M CU = 10POWER(-3)GM/CC)

Table 26b. Densities (kg/m^3) 25 to 110 km (Contd.)

KM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N
60 DEGREES N													
25	395	387	381	375	385	397	407	411	401	395	393	390	-4
30	179	175	173	173	178	183	190	192	186	180	178	178	-4
35	813	804	785	802	823	870	903	907	871	827	805	805	-5
40	361	366	365	377	399	426	444	445	422	390	367	362	-5
45	168	173	177	187	201	219	230	227	212	189	173	166	-5
50	081	085	090	098	109	119	125	122	113	097	085	080	-5
55	420	446	479	541	606	669	695	673	616	529	451	418	-6
60	218	235	258	294*	341	379	393	379	339	282	239	218	-6
65	115	122	134	155*	183*	209	219	208	182	149	124	113	-6
70	058	061	067	079*	095*	110*	117	110	093	074	063	058	-6
75	289	300	325	389*	466*	547*	587	542	451	358	303	287	-7
80	137	141	155	186*	225*	257*	265	244	200	164	144	138	-7
85	063	065	072	085*	098*	104*	103	091	081	071	066	063	-7
90	283	295	323*	353*	372*	350*	314	293	300	298	294*	286	-8
95	131*	133*	136*	135*	119*	099*	091*	096	113*	128	131*	131	-8
100	593*	578*	559*	522*	424*	328*	310*	360*	459*	546*	606*	619	-9
105	278*	254*	241*	223*	173*	132*	130*	154*	196*	239*	282*	302*	-9
110	124*	114*	111*	106*	085*	066*	062*	068*	083*	104*	129*	137*	-9
70 DEGREES N													
25	403	377	354	376	398	403	413	423	407	382	387	399	-4
30	176	168	162	174	181	187	194	196	188	175	173	176	-4
35	772	765	755	793	857	897	919	924	873	810	792	776	-5
40	338	348	356	364	399	436	452	445	416	378	361	348	-5
45	153	162	170	175	200	223	231	225	205	183	169	158	-5
50	072	077	084	089	104	120	125	120	108	093	084	076	-5
55	357	390	439	485	586	673	700	665	587	505	453	400	-6
60	192	203	233	264*	324*	380*	400	373	323	271	241	214	-6
65	100	105	121	139*	178*	213*	225	207	175	142	127	111	-6
70	050	052	059	070*	091*	113*	122	112	092	072	063	055	-6
75	241	243	282*	341*	467*	580*	625	568	454	345	299	269	-7
80	110	111	129*	162*	224*	275*	291	261	209	157	137	125	-7
85	050	049	059*	073*	099*	113*	113*	101	087*	071*	063*	057	-7
90	225	222	255*	301*	365*	365*	332*	321	329*	302*	288*	260	-8
95	103*	099*	108*	115*	122*	105*	094*	099*	123*	130*	132*	120*	-8
100	474*	439*	451*	445*	422*	345*	305*	349*	479*	553*	602*	563*	-9
105	224*	195*	200*	192*	178*	140*	125*	142*	197*	241*	281*	272*	-9
110	101*	069*	094*	095*	088*	069*	058*	062*	080*	101*	125*	124*	-9

* TEMPERATURE DATA LACKING (I.E. LESS THAN TWO DATA POINTS WITHIN ABOUT ONE MONTH AND 10 DEG LATITUDE)

VALUES FROM 25-55KM ARE BASED ON DATA AT LONGITUDES 70-160 DEG W AND DEPEND ON LONGITUDE AT HIGH LATITUDES IN WINTER. THE 60 AND 70 DEG N VALUES ARE BASED ON FORT CHURCHILL (94 DEG W) AND FORT GREELY (146 DEG W) AND AT 25-35KM ON RADIOSONDE DATA FOR 115 DEG W
VALUES APPLY TO THE FIRST DAY OF EACH MONTH

(1KG/M CU = 10POWER(-3)GM/CC)

Table 27. Log (density) for the Values in Table 26b. The annual mean value and the monthly differences from this value

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 DEGREES N													
25	*2.600	+002	+002	+000	-001	-002	-001	+002	+002	+000	-001	-002	-001
30	*2.250	+000	+000	+001	+001	+001	-002	+000	+000	+001	+001	+001	-002
35	*3.917	-003	-002	+000	+002	+002	+001	-003	-002	+000	+002	+002	+001
40	*3.608	-002	-004	-006	+000	+006	+006	-002	-004	-006	+000	+006	+006
45	*3.317	-002	-006	-007	+001	+009	+005	-002	-006	-007	+001	+009	+005
50	*3.043	-008	-008	-006	+007	+011	+004	-008	-008	-006	+007	+011	+004
55	*4.782	-014	-010	+000	+013	+011	+000	-014	-010	+000	+013	+011	+000
60	*4.532	-017	-008	+000	+014	+013	-002	-017	-008	+000	+014	+013	-002
65	*4.270	-010	-011	-004	+007	+016	+002	-010	-011	-004	+007	+016	+002
70	*5.981	-003	-007	-012	+000	+012	+010	-003	-007	-012	+000	+012	+010
75	*5.647	+001	+000	-003	-003	+001	+004	+001	+000	-003	-003	+001	+004
80	*5.289	+002	+009	+002	-004	-007	-002	+002	+009	+002	-004	-007	-002
85	*6.925	+004	+002	+000	-008	-002	+005	+004	+002	+000	-008	-002	+005
90	*6.570	-001	-013	-012	-003	+015	+014	-001	-013	-012	-003	+015	+014
95	*6.191	-020	-022	-007	+012	+023	+013	-020	-022	-007	+012	+023	+013
100	*7.802	-039	-017	+006	+026	+019	+001	-039	-017	+006	+026	+019	+001
105	*7.421	-037	+001	+024	+029	-002	-020	-037	+001	+024	+029	-002	-020
110	*7.071	-037	+026	+046	+029	-026	-047	-037	+026	+046	+029	-026	-047
10 DEGREES N													
25	*2.597	-003	-003	-009	-002	+004	+005	+004	+008	+005	-001	-002	-006
30	*2.249	-005	-008	-005	+001	+007	+003	+003	+004	+005	+001	-001	-005
35	*3.918	-007	-008	-009	-003	+002	+003	+006	+007	+007	+002	+001	-004
40	*3.608	-006	-013	-009	+001	+009	+008	+005	+005	+001	+001	+001	+000
45	*3.315	-008	-013	-009	+002	+011	+010	+003	+002	-001	-001	+002	+001
50	*3.040	-013	-014	-002	+010	+016	+010	-004	-007	-001	+003	+003	-002
55	*4.781	-016	-009	+000	+013	+017	+009	-009	-008	-003	+005	+004	-004
60	*4.528	-015	-007	+007	+016	+017	+005	-013	-015	-002	+005	+007	-007
65	*4.266	-012	-007	-006	+004	+015	+011	-003	-007	-007	-001	+009	+002
70	*5.976	-009	-015	-016	-002	+017	+019	+003	-006	+000	-001	+006	+002
75	*5.646	-012	-018	-026	-008	+015	+020	+003	+012	+017	+005	-003	-007
80	*5.292	-013	-017	-022	-013	+010	+014	+000	+016	+034	+013	-008	-017
85	*6.931	-011	-021	-032	-016	+010	+009	-003	+023	+034	+015	-002	-011
90	*6.574	-012	-039	-037	-013	+009	+005	-006	+010	+031	+024	+018	+003
95	*6.193	-030	-046	-046	+003	+026	+005	-023	+014	+034	+035	+017	+000
100	*7.805	-046	-048	-034	+007	+021	-004	-033	+013	+053	+051	+019	-015
105	*7.425	-052	-034	-029	-002	+000	-017	-03[illegible]	+033	+077	+066	+006	-037
110	*7.076	-052	-018	-009	-012	-027	-040	-027	+046	+103	+075	-011	-062

* INTEGRAL PART OF LOGARITHM , NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1KG/M CU = 10POWER(-3)GM/CC)

Table 27. Log (density) for the Values in Table 26b (Contd.)

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20 DEGREES N													
25	*2.594	+000	-007	-005	-007	-002	+003	+010	+015	+007	-001	-004	-009
30	*2.249	-010	-014	-010	-008	+000	+005	+011	+017	+008	+004	-002	-002
35	*3.919	-013	-016	-013	-004	+003	+008	+014	+012	+013	+005	-001	-010
40	*3.604	-018	-018	-013	-001	+009	+011	+014	+015	+010	+002	-003	-011
45	*3.307	-014	-018	-011	+004	+013	+014	+013	+006	+010	+002	-004	-015
50	*3.034	-018	-017	-007	+007	+014	+012	+009	+006	+007	+001	-005	-011
55	*4.776	-017	-013	-005	+009	+019	+015	+008	-002	+006	+001	-009	-015
60	*4.521	-015	-008	-001	+011	+017	+015	+008	-002	-005	-003	-004	-014
65	*4.253	-011	-012	-014	+000	+013	+020	+017	-001	+001	-005	-001	-009
70	*5.965	-008	-024	-029	-009	+017	+021	+015	+004	+008	+003	+002	-002
75	*5.641	-016	-030	-038	-002	+027	+020	+003	+003	+029	+017	-002	-015
80	*5.296	-024	-030	-034	-003	+022	+013	-007	+009	+040	+028	-003	-019
85	*6.936	-028	-024	-031	+001	+017	+003	-012	+013	+050	+032	-001	-029
90	*6.576	-033	-036	-031	+006	+016	-005	-022	+016	+045	+036	+012	-012
95	*6.188	-045	-044	-037	+025	+032	-007	-037	+010	+053	+043	+006	-015
100	*7.804	-055	-045	-038	+022	+019	-014	-039	+015	+066	+060	+010	-022
105	*7.428	-058	-031	-034	+002	+004	-026	-039	+020	+093	+080	+007	-049
110	*7.083	-067	-027	-026	-020	-021	-031	-030	+029	+104	+095	+014	-059
30 DEGREES N													
25	*2.591	-011	-012	-011	-008	-002	+002	+013	+017	+011	+005	+001	-007
30	*2.250	-016	-016	-015	-009	-001	+007	+018	+019	+016	+009	+000	-013
35	*3.919	-016	-020	-015	-008	+001	+010	+018	+022	+017	+007	-003	-015
40	*3.600	-027	-025	-018	-003	+005	+017	+023	+024	+018	+011	-010	-019
45	*3.300	-023	-028	-018	-003	+010	+020	+025	+022	+018	+005	-012	-019
50	*3.024	-026	-027	-019	+001	+013	+026	+026	+021	+014	+001	-016	-019
55	*4.765	-022	-029	-021	+000	+019	+028	+024	+019	+013	+001	-017	-021
60	*4.507	-027	-025	-023	+002	+017	+033	+029	+019	+007	+000	-017	-022
65	*4.235	-021	-029	-030	-009	+019	+039	+038	+024	+008	-011	-018	-019
70	*5.944	-021	-036	-041	-008	+024	+042	+032	+022	+008	-003	-017	-010
75	*5.622	-017	-039	-038	-003	+038	+042	+015	+012	+013	-001	-019	-011
80	*5.279	-025	-030	-030	+014	+037	+030	+002	+009	+014	+004	-017	-014
85	*6.919	-021	-024	-018	+022	+033	+018	-013	+011	+018	+006	-018	-019
90	*6.548	-018	-014	-010	+040	+026	+003	-030	-003	+009	+010	-011	-008
95	*6.151	-013	-014	-007	+051	+028	-023	-066	-007	+015	+017	-002	+009
100	*7.770	-013	-010	-010	+046	+010	-041	-071	-004	+031	+030	+003	+015
105	*7.400	-013	-007	-005	+024	-009	-050	-067	+001	+048	+041	+016	+007
110	*7.056	-028	-004	-014	+002	-028	-039	-042	-007	+047	+064	+033	+000

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1KG/M CU = 10POWER(-3)GM/CC)

Table 27. Log (density) for the Values in Table 26b (Contd.)

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
40 DEGREES N													
25	*2.592	-015	-010	-011	-014	-007	+005	+019	+019	+011	+010	+000	-008
30	*2.252	-018	-014	-012	-013	-003	+009	+018	+021	+015	+009	-001	-015
35	*3.917	-019	-020	-021	-015	-006	+011	+028	+028	+024	+010	-005	-020
40	*3.595	-030	-030	-026	-011	+002	+021	+036	+037	+026	+009	-013	-028
45	*3.293	-039	-037	-031	-010	+012	+028	+043	+046	+032	+006	-026	-038
50	*3.017	-046	-040	-034	-006	+019	+040	+047	+049	+030	-002	-033	-041
55	*4.758	-049	-041	-039	-005	+024	+042	+049	+050	+035	+002	-040	-050
60	*4.499	-056	-045	-039	-005	+030	+053	+054	+050	+033	-003	-043	-054
65	*4.224	-058	-049	-048	-009	+030	+061	+067	+061	+028	-008	-049	-058
70	*5.929	-051	-048	-048	-006	+042	+070	+071	+051	+016	-022	-055	-055
75	*5.606	-044	-045	-040	+005	+053	+069	+064	+042	+006	-035	-057	-048
80	*5.265	-033	-032	-024	+024	+059	+060	+043	+030	-010	-043	-060	-037
85	*6.899	-018	-015	-009	+040	+056	+038	+017	+012	-017	-041	-053	-025
90	*6.515	+007	+017	+016	+056	+048	+010	-035	-031	-035	-034	-032	+000
95	*6.110	+041	+044	+030	+057	+008	-071	-101	-052	-022	-002	-002	+040
100	*7.730	+064	+047	+032	+050	-023	-115	-129	-050	-009	-002	+014	+067
105	*7.369	+065	+041	+023	+034	-047	-137	-118	-038	-001	+007	+033	+080
110	*7.025	+051	+038	+018	+007	-052	-107	-089	-043	-010	+018	+052	+076
50 DEGREES N													
25	*2.594	-011	-002	-002	-016	-012	+008	+016	+012	+011	+010	-001	-013
30	*2.256	-010	-006	-009	-018	-010	+007	+016	+018	+011	+009	-003	-008
35	*3.920	-011	-018	-020	-021	-011	+010	+030	+032	+021	+002	-009	-011
40	*3.596	-027	-033	-031	-015	+001	+023	+044	+048	+031	-002	-026	-026
45	*3.293	-045	-046	-038	-009	+011	+039	+061	+060	+038	-006	-043	-047
50	*3.013	-065	-057	-041	+000	+029	+055	+071	+067	+042	-009	-059	-071
55	*4.749	-080	-066	-043	+002	+040	+063	+078	+074	+050	-009	-074	-088
60	*4.489	-094	-071	-048	+009	+048	+078	+085	+080	+051	-016	-085	-104
65	*4.215	-098	-082	-053	+002	+051	+090	+102	+089	+048	-023	-095	-114
70	*5.921	-101	-080	-055	+006	+060	+104	+112	+087	+035	-044	-105	-114
75	*5.605	-087	-075	-051	+011	+066	+104	+115	+084	+018	-062	-109	-103
80	*5.267	-073	-063	-033	+033	+078	+099	+095	+066	-003	-077	-108	-090
85	*6.899	-040	-031	-009	+050	+075	+077	+053	+027	-027	-073	-083	-059
90	*6.500	+005	+019	+038	+072	+062	+023	-027	-042	-050	-058	-048	-020
95	*6.086	+070	+076	+062	+056	-012	-105	-134	-083	-040	-011	+008	+049
100	*7.705	+105	+087	+066	+043	-062	-186	-183	-094	-038	-004	+043	+096
105	*7.348	+121	+078	+052	+022	-097	-215	-191	-087	-041	-005	+066	+137
110	*7.005	+104	+066	+045	+023	-077	-178	-159	-095	-059	-006	+078	+131

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1KG/M CU = 10POWER(-3)GM/CC)

Table 27. Log (density) for the Values in Table 26b (Contd.)

KM	MEAN	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
60 DEGREES N													
25	*2.595	+002	-007	-014	-020	-009	+004	+015	+019	+009	+002	+000	-003
30	*2.256	-004	-012	-019	-018	-006	+007	+023	+026	+013	-001	-005	-006
35	*3.921	-012	-016	-026	-017	-006	+018	+034	+036	+018	-004	-016	-016
40	*3.595	-038	-031	-033	-019	+006	+035	+052	+053	+031	-004	-031	-037
45	*3.286	-062	-049	-038	-016	+017	+055	+075	+069	+039	-011	-049	-066
50	*3.001	-096	-072	-047	-011	+036	+075	+094	+085	+050	-013	-070	-096
55	*4.737	-114	-087	-056	-004	+046	+089	+105	+092	+053	-013	-082	-116
60	*4.474	-135	-103	-063	-006	+058	+105	+120	+105	+056	-024	-095	-136
65	*4.203	-143	-115	-076	-012	+060	+117	+139	+115	+057	-030	-108	-150
70	*5.914	-150	-127	-089	-018	+062	+128	+155	+126	+056	-042	-118	-154
75	*5.606	-145	-129	-094	-016	+063	+132	+162	+128	+048	-052	-124	-149
80	*5.274	-137	-125	-082	-006	+078	+136	+150	+113	+027	-060	-116	-134
85	*6.905	-103	-089	-045	+026	+086	+114	+107	+056	+003	-051	-089	-103
90	*6.496	-045	-027	+013	+052	+075	+048	+001	-030	-019	-022	-028	-039
95	*6.079	+037	+043	+053	+050	-004	-086	-122	-097	-025	+027	+038	+036
100	*7.692	+081	+070	+055	+025	-064	-176	-200	-136	-030	+045	+091	+100
105	*7.336	+108	+068	+045	+012	-098	-214	-221	-148	-045	+041	+113	+144
110	*8.995	+098	+061	+048	+028	-066	-176	-204	-164	-079	+023	+115	+141
70 DEGREES N													
25	*2.595	+011	-019	-046	-020	+004	+011	+021	+032	+015	-012	-007	+006
30	*2.254	-008	-028	-045	-013	+005	+018	+035	+040	+021	-010	-016	-007
35	*3.918	-030	-034	-040	-018	+015	+035	+046	+048	+023	-009	-019	-028
40	*3.587	-058	-045	-036	-026	+014	+052	+067	+061	+032	-010	-030	-046
45	*3.274	-090	-065	-043	-032	+027	+075	+091	+078	+038	-011	-045	-075
50	*4.982	-126	-096	-057	-031	+036	+096	+115	+097	+049	-014	-060	-101
55	*4.717	-152	-126	-074	-031	+051	+111	+128	+106	+052	-014	-060	-114
60	*4.455	-172	-147	-086	-032	+056	+126	+147	+117	+054	-022	-072	-125
65	*4.186	-185	-166	-104	-044	+064	+142	+167	+129	+056	-033	-084	-139
70	*5.899	-202	-186	-125	-056	+059	+155	+188	+150	+066	-042	-102	-155
75	*5.594	-213	-209	-144	-061	+075	+169	+202	+160	+063	-056	-119	-165
80	*5.261	-219	-215	-152	-052	+089	+178	[illegible]	+156	+058	-064	-126	-164
85	*6.892	-190	-198	-121	-028	+104	+161	+160	+113	+045	-043	-090	-132
90	*6.473	-121	-126	-067	+006	+090	+089	+048	+033	+044	+007	-013	-057
95	*6.051	-038	-056	-016	+010	+034	-031	-080	-055	+038	+063	+069	+029
100	*7.655	+020	-013	-001	-007	-030	-118	-171	-112	+025	+087	+124	+095
105	*7.298	+052	-009	+002	-016	-047	-153	-201	-146	-005	+083	+150	+136
110	*8.957	+045	-007	+015	+020	-010	-117	-190	-168	-051	+048	+141	+136

* INTEGRAL PART OF LOGARITHM IS NEGATIVE
VALUES APPLY TO THE FIRST DAY OF EACH MONTH (1KG/M CU = 10POWER(-3)GM/CC)

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Appendix A

Method of Construction of Tables

A1. INTRODUCTION

In principle, the problem of constructing the tables presented in Section 4 was similar to that for CIRA 1965, but a much larger amount of available data required graphical methods to be replaced by computerised ones. As a result of the larger amounts of data, certain changes in the analysis procedure appeared desirable and computer processing provided a practical means of accomplishing this. Such changes are emphasized in the following sections.

A2. W-E WINDS, 25 TO 60 KM

Computer runs were made for three cases corresponding to Tables 7 to 9. In each case, mean deviations were calculated by taking the difference

$$\Delta u = u_{OBS} - u_{QB} - u_{MODEL\ 1} \qquad \text{(A1)}$$

where u_{OBS} is an observed value, and $u_{MODEL\ 1}$ is the value obtained by interpolating a given Model 1 (using second differences) at the appropriate latitude, height and date. For latitudes greater than 35°, $u_{QB} = 0$; and for those less than 35°, u_{QB} was calculated from Eq. (2) on p. 28. Ideally a correction term for

diurnal effects should be included, but adequate results have not been available (Section 2.8); and so a procedure was followed which tended to remove diurnal components, provided observations had a satisfactory distribution in local time. The values of Δu were divided into six 4-hourly groups of local time 02 to 06, 06 to 10 hours, etc., and were first averaged in each group. The average $\overline{\Delta u}$ of the six groups (or of those groups containing data if any were without data) was then obtained. Tables 13 to 16 show the number of groups containing at least one data point (G), the total number of observations (NRO) for each grouping by month and latitude, and the standard deviations (SD) of the observations from the model, for the final model. Intermediate models were obtained by the operation

$$u_{MODEL\ 2} = \left\{ u_{MODEL\ 1} + \overline{\Delta u} \right\} \tag{A2}$$

where $\{ \}$ denotes smoothing with respect to height, latitude and month.

A3. W-E WINDS, 60 TO 130 KM

Tables 10a and b resulted from an analysis similar to that described in section A2, but with the following changes:

(i) S. Hemisphere data were included with a 6-month change of date.

(ii) Prevailing wind components at 80 to 100 km from ground-based techniques were incorporated with a weighting factor equivalent to 24 individual values (supposedly taken at one-hourly intervals), thereby tying the model to the ground-based data (as a comparable number of rocket values was never available).

(iii) Due to the large amplitude of diurnal variations at greater heights, $\overline{\Delta u}$ in Eq. (A2) was set equal to zero if the averaging process for removing diurnal effects was unlikely to be effective, for example if G = 1.

(iv) At heights where the recycling of Eq. (A2) did not show convergence (due to lack of data), model values have been deleted. In fact, only at 30^{o} latitude are values given up to 130 km.

A4. TEMPERATURES, 25 TO 110 KM

Although CIRA 1965 temperature models were made consistent with the zonal wind models and the thermal wind equation, this procedure was dictated more by the lack of data then available than by arguments for the strict validity of the thermal wind equation. With more data now at hand, preliminary calculations indicate that better models would be obtained without using the thermal wind equation.

The procedure followed has been to modify an initial model T_{in} on the basis of temperature observations in such a way that a new model would have smoothly running differences in height, season and latitude. The new model T_{new} was determined on the basis of observed temperatures from

$$T_{new}(\phi) = T_{in}(\phi) + a + b\phi + c\phi^2 \quad \text{(A3)}$$

ϕ being latitude in the range (0-90°) and a, b and c being found by the method of least squares. If observations were not well distributed in latitude, either c or b and c would be set equal to zero. This procedure was repeated with T_{new} as the next T_{in} until convergence was obtained. Five-point smoothing of T_{new} in height, latitude and season was then carried out until a smooth model was obtained. It was found that convergence was more rapid below 80 km than above, where lack of data caused larger increments between successive cycles.

As only MRN temperatures up to July 1966 had been used in obtaining T_{new}, it was decided to update the models using data up to December 1968. The method involved constructing a model of differences ΔT based on the mean differences of observations from the T_{new} model at a number of sites. ΔT was then smoothed in latitude, season and height (two cycles of smoothing) and the final model was obtained as

$$T_{final} = T_{new} + \left\{ \Delta T \right\} \quad \text{(A4)}$$

After one recycling of this calculation, T_{final} had converged to within 1°K below 80 km. Above 80 km, convergence was slower due to lack of data and the value of further cycling would have been doubtful. Uncertain temperature values, taken to be those not lying within about 1 month, 10° latitude or 5 km altitude of at least two observations, have therefore been marked with an asterisk in Tables 18, 24, and 26.

A5. PRESSURES AND DENSITIES, 25 TO 110 KM

Pressure p and density ρ have been calculated from temperature T and 30 km pressures p_o by the same method as used in CIRA 1965. The formulae are:

$$p = p_o \exp \left[- \int_{z_o}^{z} Mg\, dz/RT \right]$$

$$\rho = pM/RT$$

where R = 8.3143 joule/g mole/^{o}K; and

$$g = g_{\phi} - (3.085462 \times 10^{-6} + 2.27 \times 10^{-9} \cos 2\phi)\, z$$
$$+ (7.254 \times 10^{-13} + 1.0 \times 10^{-15} \cos 2\phi)\, z^2 \quad m/s^2$$

$$g_{\phi} = 9.780356(1 + 0.0052885 \sin^2 \phi - 0.0000059 \sin^2 2\phi) \; m/s^2$$

where z is height in meters above sea level and M is mean molecular weight taken as 28.96 up to 80 km. Above this height the following values were taken: 28.95, 28.92, 28.65, 28.09, 27.69 and 27.30 at 85, 90, 95, 100, 105 and 110 km, respectively.